4-H 561GPM

National Farm and Ranch Safety

Leader's Guide

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

PennState Extension

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ACKNOWLEDGMENT

We are grateful for members on our staff for their time, editorial contributions, and assistance with photo selections. We especially thank Peggy Newell and Lisa Pfeifer.

This project was funded by USDA NIFA award numbers 2016-41521-25879 and 2017-41521-27067 as part of the Safety in Agriculture for Youth initiative.

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Contents

Note to Leaders

Tractors, Machinery, and Equipment

State and Federal Regulations

Federal and state child labor regulations prohibit certain youth from operating the agricultural equipment discussed here. In particular, youth under age 16 who are hired employees are prohibited from operating certain equipment. Exempt from federal regulations are 1) minors who work on a farm or ranch owned and operated by their parent or legal guardian, and 2) minors ages 14 and 15 who have received training and certification from an approved tractor and farm machinery safety certification program. States sometimes adopt regulations identical to federal regulations but may also have more restrictive regulations.

Farm Equipment on Public Roads

State regulations govern the operation of farm equipment on public roads. 4-H and other leaders are encouraged to investigate possible legal restrictions in their state, and to be aware of safety guidelines offered by agricultural safety and health professionals. Federal and state labor regulations can be explored at

- **dol.gov/whd/regs/compliance/childlabor102.pdf**
- **dol.gov/whd/regs/ compliance/whdfs40.htm**
- **dol.gov/agencies/whd/state/child-labor/agriculture**

Federal Child Labor Regulations

Federal child labor regulations related to agricultural work have not been updated in many years, and current regulations do not specifically address new types of machines and work processes common on today's farms and ranches. Agricultural youth safety organizations often use criteria in addition to age when considering whether youth can appropriately and safely operate farm tractors and equipment. Guidelines offered by agricultural safety and health professionals may be explored at cultivatesafety.org/work. Note the guidelines are different depending on whether the youth is working on a family farm or as hired help.

Tractor Certification

This 4-H program provides an overview of tractor operation and safety, but does not meet the requirements for tractor certification for youth ages 14 and 15. One program that does is the National Safe Tractor and Machinery Operation Program (**extension.psu.edu/business/ag-safety/youth-safety/nstmop**). Another approved program is Gearing Up for Safety (**https://www.asec.purdue.edu/tractor/index.html**).

This book includes activities for ages 8–18. Some activities are relevant to the entire age span, but others are more appropriate or more engaging for youth under age 14 and others for youth 14 and over. Activities involving the operation of a tractor are suggested as appropriate for youth ages 14–18. Leaders may decide it's not feasible to do each part of each activity suggested. Use judgment in helping the youth learn the material.

Activity Guidelines

Please use discretion in determining how much time to allow for each activity and how many youth can be in a group. If the goal is to have each youth practice each skill, be certain to allow a half day or more for each activity. If each youth is practicing a tractor operation skill, there should be no more than five youths per instructor and tractor. If only a couple of youths will try each activity, and the others will watch, then each instructor may be able to accommodate more than five youths in an hour for some activities.

Some of the activities are season-specific e.g., watch a silo-filling operation. Reviewing all the activities and possibly conducting some out of order may be necessary to take advantage of the time of year.

Bolded words in green are listed in the glossary at the end of the book.

Education Standards

Every activity cites the relevant national agriculture, food, and natural resources (AFNR) career cluster content standard(s), including career-ready practices, and where appropriate, cluster skill CS.03: Examine and summarize the importance of health, safety and environmental management systems in AFNR workplaces. The standards can be viewed in their entirety at **theaet.com/docs/council_afnr_career_cluster_content_standards.pdf**.

Pesticides and Youth

Modern farming practices use pesticides, when needed, to produce and preserve an abundance of high-quality food and other agricultural commodities. The **Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)** is the federal law pertaining to pesticides. The U.S. Environmental Protection Agency (EPA) administers FIFRA. Under FIFRA, individuals must become certified to use certain pesticides registered by EPA. EPA classifies these **restricted use pesticides (RUPs)** because they demand special attention due to their suspected ability to harm people, livestock, wildlife, or the environment even when used according to label directions. To become certified, an individual must demonstrate a base level of competency of understanding how to use these products properly. This is traditionally accomplished through an exam.

EPA is currently seeking input on federal standards regarding age requirements for individuals seeking certification as a pesticide applicator. Like the age restrictions pertaining to equipment use, child labor laws also apply to the use of pesticides, and states may have their own age restrictions for handling or exposure to pesticides. For example, in states that follow federal **Hazardous Occupations Orders for Agriculture (AgHOs)**, a youth has to be at least 16 years of age to work for hire and handle pesticides. Visit **dol.gov/agencies/whd/state/child-labor/agriculture** to see how states address child labor regulations as they relate to agricultural employment. These issues may be discussed with youth.

EPA is in the process of adopting revisions to the federal certification and training requirements in FIFRA to establish a minimum age for pesticide certification and use. EPA is proposing that individuals must be at least 18 years old to become certified as either a private or commercial applicator. In addition, EPA is proposing anyone using a restricted use pesticide under the supervision of a certified applicator would also have to be at least 18 years old. Both of these age requirements are close to being finalized by EPA.

Another regulation under FIFRA is the **Worker Protection Standard (WPS)**, which pertains to the protection of agricultural workers and handlers from occupational exposure to pesticides in agricultural operations. Under the WPS, “early-entry workers” and pesticide “handlers” must be at least 18 years old, with the exception of immediate family members of the owner of the agricultural operation. An early-entry worker enters an area after a pesticide has been applied, but before the required elapsed time specified on the product label, known as the restricted entry interval (REI). Under the WPS, handlers are individuals who handle or assist with the mixing, loading, applying, or disposal of pesticides.

Although family members working on the farm are likely exempted from pesticide regulations under any revisions to official guidelines, applicators need to be aware of the risks when using pesticides. Applicators must use pesticides properly and minimize the potential risks associated with their use. By law, pesticides must be applied according to the instructions on the label. This helps ensure pesticide products are used properly, minimizing any potential risks to the applicator, other people, or the environment. These are good practices to follow regardless of an individual's work (or family) status.

Additional Resources

Interactive Tool to Judge Youth Readiness for Farm Work

Youth must perform tasks matching their developmental level and abilities to reduce their risk of injury. Farmworkers face hazards not encountered in other jobs. The National Children's Center for Rural and Agricultural Health and Safety has developed an interactive website, **cultivatesafety.org/work**, to help farm supervisors assess youth readiness to do many different farm jobs. The site features guidelines for both family and nonfamily farmworkers. Use these guidelines to help determine if a youth is ready to perform a job and to learn more about hazards and keeping working youth safe.

Free Resources

Many free resources demonstrate farm equipment safety and are available at **ag-safety.extension.org/machinery-and-equipment-safety-video-resources** and **ag-safety.extension.org/general-farm-and-ranch-safety-video-resources.**

Penn State Spanish-Language Tractor Safety Videos

youtube.com/playlist?list=PL8hJRvD_GIH6m0dWZooJWqxtUJXP1jrga

SAY National Clearinghouse

The goal of the SAY National Clearinghouse is to serve as a sustainable and accessible clearinghouse for agricultural safety and health educational resources for youth. It can be accessed at **ag-safety.extension.org/safety-in-agriculture-for-youth**.

The Progressive Agriculture Foundation

The Progressive Agriculture Foundation operates Progressive Agriculture Safety Days and has many resources for youth safety. To access these resources, including lesson plans, hands-on activities, and safety demonstrations geared toward children, apply to host a Progressive Agriculture Safety Day at **progressiveag.org/GetInvolved.cgi**.

Ohio State University Extension

Ohio State University Extension offers a Farm Safety Learning Lab Kit with engaging and durable materials that support many of the hands-on activities included in this leader's guide. Learn more at **extensionpubs.osu.edu** (search for "kit").

Introduction

Children[1] play an active role on many farms[2]. The adults around them are responsible for warning them about hazards on the farm and teaching them safe work habits.

The combination of many factors complicate farm safety. Farm work must often be completed regardless of weather extremes; work sites often overlap with residences; and daycare may be unavailable, inconvenient, or unaffordable. The work pace can be highly erratic. Farmers often rely on their own knowledge and awareness of hazards to work safely. Some tasks are done only once or twice per season or year, and farmworkers are typically expected to be jacks-of-all-trades.

Figure 0.1 Credit: PSU Ag Safety.

Figure 0.2 Credit: Central States Center for Agricultural Safety and Health.

The range of hazards in the agricultural workplace results from daily exposure to powerful machines and chemicals, from repetitive day in, day out activity, and from the stress of second-guessing the crops, the weather, the pests, and more. Agricultural workers must face these hazards every day.

The most common causes of agricultural-related fatalities for children are machinery or tractor incidents, drowning, and motor vehicle accidents, including those involving all-terrain vehicles (ATV). Most nonfatal injuries result from falls or incidents with livestock (figure 0.1).

Agricultural hazards take a heavy toll. Farming remains one of the most dangerous occupations, yet serious incidents rarely make the news. Instead of a dramatic story in which dozens are killed or injured, agricultural losses are a steady drip, drip, drip—a tractor overturn here, a confined space injury there, an unfortunate encounter with a bull or horse somewhere else. These add up, and almost every farm family has stories to tell.

Children are often eager to work on the farm alongside other family or team members. They must understand each farm task has a certain level of risk associated with it. Children working on a farm need the appropriate physical and cognitive maturity to complete any assigned tasks (figure 0.2), as well as appropriate supervision.

This book provides an overview for 4-H and other youth leaders and volunteers of the safety and health considerations for youth ages 8–18 who live and/or work on farms throughout the United States. Parents, caregivers, or supervisors must assign youth age-appropriate tasks, restrict access to certain work areas, give easy-to-understand instructions, provide personal protective equipment (PPE) when needed, maintain

[1] Adapted from Age-appropriate tasks for children on farms and ranches. (2012) Farm and Ranch eXtension in Safety and Health (FReSH) Community of Practice. Retrieved from **ag-safety.extension.org/safety-in-agriculture-for-youth**.

[2] The word "farms" is used generally here and elsewhere in this publication. It refers to farms, ranches, rural estates, and anywhere else these situations and equipment are encountered.

equipment with operational safety devices, and provide supervision to reduce the risk of injury or death.

U.S. Youth Farm Accident Statistics[3]

Some people may think, "I'm always careful! I'll never suffer a work injury!" This type of thinking is what causes injuries and kills hundreds of workers in farm accidents each year.

Fatality Facts

- Every three days, a child dies in an agriculture-related incident.
- Of the leading sources of fatalities among all youth, 25% involved machinery, 17% involved motor vehicles (includes ATVs), and 16% were drownings.
- For working youth, tractors were the leading source of fatalities followed by ATVs.
- Youth agricultural deaths cost society an estimated $515 million per year (2016 dollars).

Injury Facts

- Every day, about 33 children are injured in agriculture-related incidents.
- About 7,500 household youth (who live on a farm) are injured annually on a farm, and 60% of them were not working when the injury occurred.
- Nearly 750 hired youth are injured annually on farms.
- More than 3,700 visiting youth are injured on farms each year.
- Vehicles are the leading source of injury for household working youth.
- Youth agricultural injuries cost society an estimated $1.2 billion per year (2016 dollars).

The work death rate per 100,000 workers regularly ranks agriculture among the most hazardous industries in the country. Youths are included in these injury numbers. Other industries with serious work hazards, such as mining and construction, do not have a youth injury problem because children younger than 16 do not usually work in these industries.

Accurate numbers of youth work fatalities and injuries are difficult to determine because youth do not work regularly enough or in large enough numbers to be counted in most official injury statistics. As a result, the statistics provided are considered lower than what the actual numbers may be.

Youth workers are often assigned tasks presenting several hazards. Machinery, ATVs, and falls account for most farm injuries and fatalities.

Laws Governing Agricultural Work by Youth

The Fair Labor Standards Act (FLSA) is a federal regulation governing the employment of children in both agriculture and general industry. In 1968 the Fair Labor Standards Act of 1938 was amended to include the Hazardous Occupations Orders in Agriculture (Ag HOs). The orders require youth be at least 16 years old to work in agriculture, or 14 years old with special training. The order also identified several hazardous farm tasks, such as operating a tractor over 20 horsepower and operating specific kinds of farm machinery. Exempt from this law are (1) minors who are employed or working on a farm owned and operated by their parents or guardians, and (2) minors ages 14 and 15 who receive training and certification from an approved tractor and farm machinery safety program. Each state provides or designates an approved training to meet this requirement. One example of such a training is the National Safe Tractor and Machinery

3 National Children's Center for Rural and Agricultural Health and Safety. 2022. "2022 Fact Sheet Childhood Agricultural Injuries." Marshfield, WI: Marshfield Clinic Health System. PDF. marshfieldresearch.org/Media/Default/NFMC/National%20Childrens%20Center/2022_Child_Ag_Injury_Fact_Sheet.pdf.

Operation Program (**extension.psu.edu/business/ag-safety/youth-safety/nstmop**) from Penn State Extension. Employers can be penalized with fines or imprisonment for subjecting youth to hazardous occupations.

Youth younger than 14 cannot be hired to operate tractors or machinery (figure 0.3).

Additional regulations of the Occupational Safety and Health Administration (osha.gov) may apply to farms hiring nonfamily labor. These regulations were created to save lives, prevent injuries, and protect the health of all American workers. Farms hiring 10 or fewer employees fall under the small farm exemption and may not be inspected for OSHA compliance, although the regulations still apply.

Another regulation that applies to many farms is the Worker Protection Standard (WPS) of the U.S. Environmental Protection Agency (EPA). This regulation aims to reduce the risk of pesticide poisonings and injuries among agricultural workers and pesticide handlers. The WPS specifies these requirements:

- pesticide safety training
- notification of pesticide applications
- use of personal protective equipment
- restricted entry intervals following pesticide application
- decontamination procedures and supplies

Child Development Related to Agricultural Work and Safety

Traditionally, farming has been a family affair with children working on their own family's farm. Larger farms may hire youth for work as well. Farming offers a unique opportunity for children and adolescents to learn the value of hard work, how to handle

Figure 0.3 The old wooden floor gave out beneath this tractor in a 19th-century barn. Credit: Joy Drohan.

responsibilities, and how to set priorities. Leaders and volunteers in 4-H play an important role in reinforcing safe farm activities.

Although young workers gain personal development benefits, there are also risks. Every child grows and develops physically and mentally at a different rate. Parents and supervisors need to assess the youth's development, assign age-appropriate tasks, and provide appropriate levels of supervision. A child's size, strength, motor skills, and coordination are all factors in determining whether they are physically able to complete certain tasks. Adults who supervise youth must determine whether a child has the cognitive skills to understand and follow instructions, make good decisions, and realize unsafe actions may lead to injury or even death. Table 1 shows developmental characteristics typical of ages 0–18 years and suggests age-appropriate safety strategies.

Table 1. Child development and farm safety. (From Cultivate Safety, National Children's Center for Rural and Agricultural Health and Safety, **cultivatesafety.org/wp-content/uploads/2016/08/Cultivate-Safety-Child-Dev-Chart.pdf**)

Child Development and Farm Safety

Age	Developmental Characteristics	Safety Strategies
0–6 years old	• Rapid physical and mental growth • Motor skills developing • Difficulty with balance • Slow reaction time • Curious, exploring • Fascinated by movement • Imaginative thinking • Energetic • Little sense of danger and risk	• Model safe behavior • Keep child out of the farm worksite • Never allow child as extra rider on tractor • Install physical barriers around farm worksite hazards • Provide close supervision in fenced play area or indoors • Reward safe behavior
7–9 years old	• Steady growth • Developing hand-eye coordination • Operates with concrete facts • Curious abut how things work • Poor attention span • Stays active • Wants to appear conpetent • Wants to try tasks without supervision • Not ready for significant responsibility • Unaware of many dangers and risks in the environment	• Model safe behavior • Set and enforce consistent rules • Reward safe behavior • Assess readiness to do jobs • Do not assign jobs that require hand-eye coordination • Repeatedly show child how to do the job safely • Limit job to 15 minutes • Provide continuous and close supervision
10–12 years old	• Steady growth • Coordination improving, but still awkward at times • Improved reaction time • Strength and dexterity increase • Desires peer and social acceptance • Desires independence from adults • Attempts tasks without supervision • Success important for self-concept • Does not fully understand consequences of actions • Easily distracted	• Model safe behavior • Set and enforce consistent rules • Reward safe behavior • Assess readiness to do jobs • Show child how to do the job safely on several occassions • Limit job to 20 minutes • Provide close supervision • Provide appropriate personal protective equipment
13–15 years old	• Rapid growth, changing physically • Moving to abstract thinking • Can have trouble making good decisions • Still needs adult guidance • Desires peer acceptance • Resists adult authority • Feels immortal and invulnerable	• Model safe behavior • Set and enforce consistent rules • Assess readiness to do jobs • Show child how to do the job safely • Frequently reassess job assignments • Slowly increase complexity of jobs • Check the child every 20 to 30 minutes to assess for fatigue/inattention and provide work breaks • Provide close supervision based on job hazards and the work environment • Provide appropriate personal protective equipment
16–17 years old	• Physical growth slowing • Sexual maturity reached • Learning to think abstractly • Does not always consider consequences of actions • Peer influence remains strong • Poor ability to control impulses • Feels immortal and invulerable • Desire to behave independently from adults • Still dependent on parents • Not yet thinking at adult level in many domains	• Model safe behavior • Set and enforce consistent rules • Assess readiness to do jobs • Show child how to do the job safely • Slowly increase complexity of jobs • Check the child every 30 minutes to assess for fatigue and provide work breaks • Provide close supervision based on job hazards and the work environment • Provide appropriate personal protective equipment

The National Children's Center for Rural and Agricultural Health and Safety developed the Ag Youth Work Guidelines. This is a searchable database (**cultivatesafety.org/safety-guidelines-search**) allowing adults to identify a farm task and follow a checklist to determine a child's ability to complete the task.

Everyone goes through growth phases. Physical and mental maturity must match work assignments.

Age-Appropriate Farm Tasks and Adult Roles

Adapted from Cultivate Safety, National Children's Center for Rural and Agricultural Health and Safety, **cultivatesafety.org/work**.

Ages 7–9

Children ages 7–9 are developing hand-eye coordination, are curious about how things work, have a poor attention span, and are unaware of many dangers and risks in the environment.

What can these children do?

- hand weed
- hand harvest berries
- hand harvest vegetables
- pick rock

What should these children not do?

- work or play around large animals
- work or play around tractors and machinery
- be an extra rider on a tractor
- drive an ATV too large for them to handle or without protective gear

What should adults do?

- model safe behavior because children are watching
- assess child's readiness to do the job
- show child how to do the job safely
- limit job to 15 minutes or less
- provide continuous and close supervision

What should adults not do?

- conduct farm work and try to supervise a child at the same time
- assume a particular child is "mature" and able to handle tasks beyond their ability

Ages 10–12

Children ages 10–12 have improving coordination and reaction times, but are easily distracted and do not fully understand the consequences of their actions.

What can these children do?

- hand harvest strawberries and vegetables
- pick rock
- feed milk to calves
- clean service alley in barn
- some other animal feeding activities

What should these children not do?

- work activities with large animals
- operate tractors and machinery
- be an extra rider on a tractor
- drive an ATV too large for them to handle or without protective gear

What should adults do?

- model safe behavior—children are watching
- assess child's readiness to do the job
- show child how to do the job safely
- limit the job to 20 minutes, then assess fatigue and provide a work break
- provide close supervision based on job hazards and the work environment
- provide appropriate personal protective equipment

What should adults not do?

- conduct farm work and try to supervise a child at the same time
- rush learning by assuming a child can learn quickly
- assume a child's work will be the same quality and completed at the same speed as adults

Ages 13–15

Children ages 13–15 are growing rapidly and changing physically. They can have trouble making good decisions and they resist adult authority.

What can these children do?

- most can work with large animals
- detassel corn
- clean calf pens and hutches
- repair fences
- run pressure washers
- operate farmstead equipment

What should these children not do?

- harvest tree fruit from a ladder
- operate tractors on public roads
- handle farm chemicals
- work with bulls
- work in grain bins, silos, or manure storage facilities
- be an extra rider on a tractor
- drive an ATV too large for them to handle, without protective gear, or under the influence of alcohol or drugs

What should adults do?

- model safe behavior—children are watching
- assess child's readiness to do the job
- show child how to do the job safely.
- provide close supervision based on job hazards and the work environment
- provide appropriate personal protective equipment
- check with the child every 20–30 minutes to assess fatigue and provide work breaks

What should adults not do?

- conduct farm work and try to supervise a child at the same time
- rush learning by assuming a child can learn quickly
- assume a child's work will be the same quality and completed at the same speed as adults
- assume a child can do the same work as an adult

Ages 16–17

Children ages 16–17 are learning to think abstractly, but they do not always consider the consequences of their actions. They want to be independent from adults, but are not yet thinking at adult levels.

What can these children do?

- most can work with large animals
- most can work with tractors and implements
- farm work with ATVs
- most jobs involving working at heights
- operate a skid steer

What should these children not do?

- work with bulls
- work in grain bins, silos, or manure storage facilities
- pull oversize or overweight loads
- hitch a tractor to move stuck or immovable objects
- be responsible for supervising other young workers
- apply pesticides and/or anhydrous ammonia
- be an extra rider on a tractor
- drive an ATV without protective gear or under the influence of alcohol or drugs

What should adults do?

- model safe behavior—children are watching
- assess child's readiness to do the job
- show child how to do the job safely
- provide close supervision based on job hazards and the work environment
- provide appropriate personal protective equipment
- check with the child every 30 minutes to assess fatigue and provide work breaks

What should adults not do?

- conduct farm work and try to supervise a child at the same time
- rush learning by assuming a child can learn quickly

- assume a child's work will be the same quality and completed at the same speed as adults
- assume a child can do the same work as an adult

Physical growth can lead youth to believe they can do more than they can mentally handle.

Supervision

From Cultivate Safety, National Children's Center for Rural and Agricultural Health and Safety, (**cultivatesafety.org/supervision**)

Adult supervision is careful, directed attention provided to a child or teenager doing farm work. The amount of supervision depends on the age of the youth and the task being performed.

Levels of Supervision

Constant—an adult is always within sight, sound and reach of a youth

Intermittent—an adult is out of sight and sound for up to 15 minutes

Periodic—an adult observes the youth at least every 15–30 minutes

Key Points

- No task is too easy; youth must always be supervised by an adult.
- All children under 10 years of age need constant supervision.
- Recommended levels of supervision for youth over 10 years depend on the youth's age and the task.
- Youth performing a new task should be constantly supervised until competent.
- Adults should not perform farm work while supervising youth, unless demonstrating a task or training them.
- Provide frequent rest periods and monitor youth for fatigue.
- Monitor youth for good body mechanics and provide training as needed.
- Adults should immediately correct unsafe behaviors.

ACTIVITY 0.1

Age-Appropriate Tasks

LEADER NOTES

Skill Level: Beginner

Learner Outcomes: Understand that youth should not perform some farm tasks. Understand farm tasks that are appropriate for their age and the dangers of performing age-inappropriate tasks.

Education Standard(s): CRP.01. Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–3 on the “Let’s Do It” page and can name some tasks that are appropriate for their age and others that are inappropriate for their age. Youth understands why certain tasks are off limits.

Life Skills: Analysis, writing, memory, discussion, public speaking

Tags: Age-appropriate tasks, risk

Time Needed: 1 hour

Materials List:

- copies of Let's Do It
- pens/pencils
- computers with internet connection

Space: Classroom or other indoor space

Suggested Group Size: Maximum of 10 people; could have youth discuss in groups of two or three

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual*, 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Review the Cultivate Safety task sheets (**cultivatesafety.org/work**) for some common farm tasks in your area. Read the Variations section below to decide how you want to present the activities.

Variations: If internet access is unavailable, prior to the meeting print out various Cultivate Safety task sheets for common farm tasks in your area so the kids can work from those.

Make a list of various farm tasks and ask the youth what age kids should do them. Discuss any tasks they have wrong.

Introduction: See the Child Development as Related to Agricultural Work and Safety section in the Introduction.

Opening Questions: Have you ever performed a farm or ranch job that scared you, maybe because you were unsure about how to use the equipment, or because the equipment moves so quickly or is so sharp?

ACTIVITY 0.1

Age-Appropriate Tasks

LET'S DO IT!

1. Use the Cultivate Safety website (**cultivatesafety.org/work**) to explore task sheets for one or more of the jobs you do. Write down any violations of recommended procedures you've seen or done.

What do your answers tell you about how safe you've been in the past? List some changes you can make in your behavior to become safer.

2. Recall a hazardous situation you encountered and write it down. How do you think your age at the time influenced the outcome? How would you handle the situation differently now to be safer?

3. Share your story from above (or a different hazardous incident) with a partner or the group. Describe any general themes you see among the stories.

Reference:

Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual*, 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More

"Age-appropriate tasks for children on farms and ranches." (2012) Farm and Ranch eXtension in Safety and Health (FReSH) Community of Practice. Retrieved from **extension.org/pages/63149/age-appropriate-tasks-for-children-on-farms-and-ranches**

Choosing Age-Appropriate Chores: Keep Kids Safe by Selecting Tasks They Are Physically and Mentally Ready to Handle." L. Prater. 2016. **agriculture.com/jsa**

Chapter 1
Safety Basics

Risk Perception

Why do people take risks? Has past experience taught them taking risks is acceptable? Have they also learned risk-taking increases their chances of injury? A person's risk perception (how they judge risk) about work situations comes from personal opinions and prior experience.[4]

The Nature of Risk

People risk their lives and health each day. Some risks are minor. No one expects to be injured walking around the house, for example. Other risks are major. Driving too fast increases the risk of a crash and possible injury. Risk is the chance of being injured by a perceived hazard.

Risk can be measured with probability (odds). What are the odds someone may be injured by a specific hazard? Risk also measures the chance of hazards causing serious injuries. Risks can be negligible (a splinter) to great (permanent disability or death).

Risk perception is an important concept in safe work activity. Human perceptions of risk are not very accurate.

People's judgments about risks are based upon several things. One important factor is how familiar they are with a hazard. If they think they know a lot about a hazard because they are often exposed to it, they often underestimate the degree of risk.

Another factor is whether or not they are voluntarily interacting with a hazard. When people voluntarily take a risk, they usually underestimate the chances of being hurt.

A third factor is how much attention a hazard brings if it hurts someone. People tend to think there is a great risk in flying in an airplane, because a crash may kill many people at one time and get a lot of attention. They underestimate the hazard of driving a car. Automobile crashes typically kill one or two people at a time and receive only local attention.

People must understand risk, the probability of danger, and the potential personal consequences.

To reduce risks, people must understand the consequences of their own actions.

[4] Unless otherwise noted, all text in this chapter is adapted from *National Safe Tractor and Machinery Operation Program, Student Manual*, updated 2nd ed., developed by agricultural health and safety experts at The Pennsylvania State University, The Ohio State University, and the National Safety Council. Hobar Publications.

Probability

Work, and all other activity, involves risks. What are the odds (or chances) of injury while engaged in an activity? Probability involves a study of the odds or chances of a single event actually occurring out of the possible times it could occur. For example, when a single die is rolled, the odds of rolling a 1 are 1 out of 6.

Safety experts have rated the probability of exposure to risks in several ways. One rating system uses a time frequency that can be measured. The frequency rating system includes these categories:

- **Frequent exposure**—Probability is likely/possible on a daily basis. As an example, daily handling of livestock (figure 1.1) represents frequent exposure to this hazard.
- **Probable exposure**—Probability is likely/possible on a weekly or monthly basis. As an example, weekly or monthly work in the hay loft gives a probable exposure to the hazards of a fall.
- **Occasional exposure**—Probability is likely/possible over a year or multiple years. As an example, yearly weaning of calves provides occasional exposure to the risk of injury by a cow.
- **Remote exposure**—Probability is not likely, but is possible over many years, even a lifetime. As an example, the owner of a barn probably paints the barn roof only rarely, so the exposure to a fall injury is considered a remote probability. A professional barn roof painter, however, is frequently exposed.
- **Improbable exposure**—Probability is unlikely, but still possible. As an example, nuclear power radiation poses an improbable exposure.

These probability ratings demonstrate less exposure to risk gives lower odds of injury or death.

Figure 1.1 Credit: Central States Center for Agricultural Safety and Health.

Consequences of Risk Exposure

Just as the probability of risk exposure was assigned measurement categories, the consequences of risk exposure can be assigned measurement categories as well.

- **Catastrophic severity**—Catastrophic injury or death is very possible. As an example, death can easily result from rollover of a tractor without rollover protection (ROPS) (figure 1.2).

Figure 1.2 Credit: J. Mathison.

- **Critical severity**—Severe or permanent injury, long-term illness, and temporary property loss is possible. As an example, trying to step over an unguarded **power takeoff (PTO)** shaft (figure 1.3) while it is running can lead to entanglement and potential loss of a leg. (A PTO shaft is a means of transferring mechanical power between farm tractors and implements.) Note that words in **bold** throughout this book are defined in the glossary.

Figure 1.3 Credit: J. Mathison.

- **Marginal severity**—Less serious risk exposure with shorter term losses. As an example, falling from a horse and breaking an arm is less severe than having an arm amputated due to machine entanglement.
- **Negligible severity**—Risk exposure event results in need for first aid, or property losses that are easily repaired. As an example, a splinter from plywood can be treated with basic first-aid supplies. If the splinter caused the plywood to be dropped, the loss is slight.

The probability of risk exposure and the consequences of the risk can then be treated as an equation to describe how to reduce risk.

1. Use the risk matrix table below to determine the risk of climbing over a turning, unguarded PTO shaft every day.
2. Think of a different work activity and rate the severity of the risk.

Table 1.1. Applying a risk matrix table to reduce risk probability

	Severity	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequency	Frequent (A)	Shut down immediately; correct problem	Shut down immediately; correct problem	Correct ASAP	Correct sometime
	Probable (B)	Shut down immediately; correct problem	Correct ASAP	Correct soon	Correct sometime
	Occasional (C)	Correct ASAP	Correct soon	Correct sometime	Correct sometime
	Remote (D)	Correct sometime	Correct sometime	Correct sometime	Correct sometime
	Improbable (E)	Correct with preventive maintenance	Correct with preventive maintenance	Correct with preventive maintenance	Correct with preventive maintenance

Mechanical Hazards

There are many hazards associated with mechanical equipment in agriculture. Knowing every hazard of every machine is difficult. Agricultural safety and health professionals group hazards to help operators recognize different types of hazards regardless of the machine. Recognizing these hazardous components is the first step in being safe.

This section identifies groups of hazards, explains the danger, where the hazards may be found, and gives instruction for avoiding them.

Pinch, Wrap, and Shear Points

A **pinch point** hazard forms when two machine parts move together and at least one of the parts moves in a circle (figure 1.4). These types of hazards are often found in power transmission systems such as belt drives, chain drives, and gear drives. ***Avoid pinch points by keeping machine guards in place.***

Any type of rotating machine component can be a **wrap point**. The rotating components are often shafts, such as the power takeoff (PTO) (figure 1.5). A person can be caught in a wrap point by loose clothing or long hair. ***Guards can protect the operator from wrap points. Wearing properly fitting clothes and tying up long hair is important.***

A **shear point**, also called a cut point, occurs when the edges of two machine parts move across or close enough to each other to cut a relatively soft material. At least one of the two objects must be moving. Hedge trimmers are a good example of a machine with a shear point.

Shielding the worker from the shear point is difficult on many agricultural machines. ***The best precaution to take for preventing injury is to shut off the machine before making repairs or adjustments.***

Awareness is the best protection from hazards that cannot be eliminated or shielded.

Crush, Pull-in, and Burn Points

Crush points are formed when two objects move toward each other, or when one object moves toward a stationary object, and the gap between the two decreases. The most common example of a crush point occurs when an implement is attached to a tractor's drawbar. Most often the tractor is moving toward a stationary implement, and the gap between the tractor's drawbar and the implement's hitch decreases. ***Do not permit anyone to stand between the tractor and the implement while hitching.***

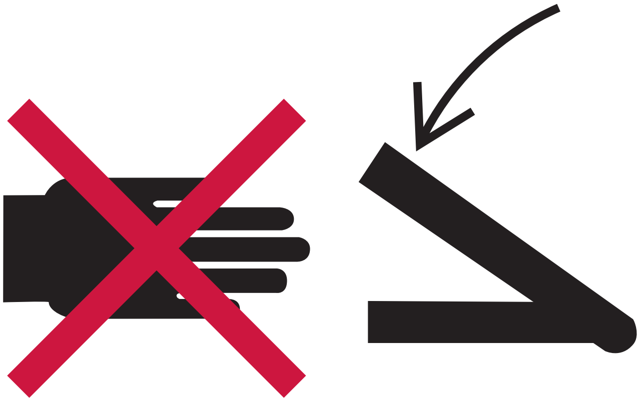


Figure 1.4 Pinch points can be found on most machines. This is the symbol for pinch point. Credit: Association of Equipment Manufacturers.

Figure 1.5 A properly guarded PTO will protect against the entanglement hazard. Credit: Central States Center for Agricultural Safety and Health.

Pull-in points (figure 1.6) occur most often where crops are fed into harvesting machinery. Rotating parts in close contact with each other, such as feed rolls, often form pull-in points. Moving components, such as feed chambers on square balers also form pull-in points. ***To avoid being pulled into a machine, shut down the engine and the PTO before making repairs or adjustments.***

Figure 1.6 Pull-in points are found on harvesting machinery. This is a symbol for pull-in point hazard. Credit: Association of Equipment Manufacturers.

Hot mufflers, engine blocks, pipes, and fluids (fuel, oils, chemicals) are all examples of possible **burn points** on tractors, self-propelled machinery, and pulled machinery. Machine inspection, servicing, and maintenance are the most common activities exposing a burn point hazard. ***To avoid burns, do not touch the engine or machine parts when inspecting them. Place hand near the surface of the part to determine if a part is hot.***

Freewheeling Parts

Parts of a machine continuing to move after the power to the machine has been turned off, are called **freewheeling parts** (figure 1.7). These hazards exist because many machines require a large amount of rotational force to keep them running smoothly under irregular loading. Stopping this rotational force suddenly is almost impossible. A small, rectangular baler flywheel is an example of a freewheeling hazard.

To avoid injury from freewheeling parts, stop the tractor engine, disengage the PTO, and wait for the machine to stop completely before making repairs or adjustments.

Figure 1.7 The flywheel on a small square baler is an example of a freewheeling part. The flywheel keeps the baler running smoothly if a large amount of hay is suddenly taken into the bale chamber. The PTO is properly guarded. Credit: J. Mathison.

Stored Energy

Stored energy hazards occur when confined energy is released unexpectedly in pressurized systems and their components. Examples include springs, hydraulic (figure 1.8), pneumatic, and electrical systems. ***Know which parts may be spring loaded and relieve hydraulic system pressure when the job is completed. Ask for a demonstration of where this potential hazard might exist.***

Figure 1.8 Hydraulic systems such as this telehandler often have stored energy. Credit: J. Mathison.

Thrown Objects

Thrown object hazards occur as normal machine operations discharge materials into the surrounding environment. These hazards are formed by rotating fan or knife blades that cut, grind, or chop materials. The blades can throw small or large objects (figure 1.9), such as glass, metal, rocks, sticks, or other vegetation. A common example of a thrown object hazard is the material discharged from a rotary mower. ***To avoid injury from thrown objects, be sure the machine is at a complete stop before nearing the discharge area. Keep the work area clear of bystanders. Wear eye protection when working with this type of hazard.***

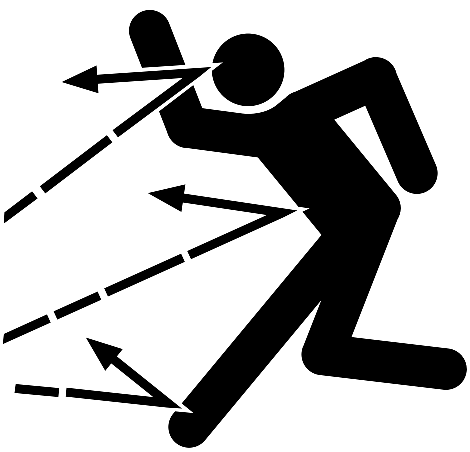


Figure 1.9 Mowers are a frequent source of thrown objects. This is the symbol for thrown object hazard. Credit: Association of Equipment Manufacturers

The ability to identify hazards is the first step in avoiding them.

Reaction Time

How fast can people react? **Reaction time is the time it takes for a person to respond to an event or an emergency.** Emergencies occur without warning. Past experiences, along with reaction time, determines emergency response to an event. There is no time to think about what to do.

Recognize personal reaction time is slower than the speed of a machine.

Reactions Are Complex

Reacting to an emergency involves a complex sequence of events. Consider this scenario: an animal jumps in front of someone on a bike, traveling down the road. What happens next?

- Their eyes gather the information, "animal in road," and send a message to their brain.
- Their brain receives and processes the information and sends a response to their arms and legs.
- Their muscles must apply the brakes.
- The bike continues to move as they respond until it finally stops, hopefully before they hit the animal.

Here are a few more examples of emergency situations:

- Accidentally touching a hot stove.
- Recognizing a shirt sleeve is being caught on the drill press.
- Realizing a shoestring is dangling over the PTO shaft, which no one should step across.
- Pulling a tractor and load onto the roadway and seeing a fast-moving vehicle.
- Trying to unplug a corn harvesting machine while it's running, and being pulled into the gathering chains.

Many factors affect reaction time. **People cannot beat a machine—ever! Lives depend on this information.**

Factors Affecting Reaction Time

- Experienced operators gain knowledge of potential hazards as they work. Beginning operators may not know where danger lies.
- Healthy, well-rested operators think through hazardous situations more clearly than fatigued workers.
- Distracted or daydreaming operators are less cautious than focused workers.

- Frustrated or uncomfortable workers (too hot, too cold, wet) tend to make bad decisions.
- Medications, as well as drugs, alcohol, and tobacco, can slow reaction time.
- Machine vibrations fatigue operators and reduce reaction time.
- Poor vision and hearing can lead to poor reaction time.

Think, "What is the worst thing that can happen?" A few seconds of thought can prevent injury or death.

Rotating Parts Are Everywhere

People are exposed to serious hazards when they work around or near shop equipment, machinery, or tractors. Rotating parts are everywhere. Some examples:

- grinding wheels
- drill presses
- chain saws
- lawn mowers, weed trimmers, hedge trimmers, etc.
- augers
- belts and pulleys
- chains and sprockets
- gears
- power takeoff (PTO) shafts

All exposed rotating parts of farm tools and equipment spin faster than someone can pull away should they become entangled.

PTOs and Reaction Time

Some people think they are faster than a speeding machine. Although they have been warned not to step over a turning PTO shaft, PTO entanglements still happen. Consider how fast the shaft spins versus a typical person's reaction time, which is ¾ of a second.

Let's say an unguarded PTO shaft is turning at 540 rotations per minute (rpm) or 9 rotations per second. They decide to step over it to save a few steps and seconds, rather than walk around the tractor or piece of equipment. They feel a tug on their pants leg. They are caught. The shaft will turn six times before they realize they are caught and begin to pull away, if they can at all.

To avoid rotating part entanglements:

- Keep guards in place on rotating shafts and other parts.
- Stop the engine before dismounting the tractor.
- Dress safely to avoid entanglement (see below).
- Think before taking a chance: "Is saving a few seconds or steps worth risking my life?"

As discussed in the Introduction, farm safety demands youth are assigned age-appropriate tasks. Review the discussion in the Introduction before beginning any new farm task.

Dress for Safety

When people go to work, they should dress for the work they will do. A good candidate for work at a farm in does not arrive wearing

Figure 1.10 Safely dressed workers wear the clothing and equipment needed to do the job without risk. Credit: J. Mathison.

sandals. Think about safety when dressing for work on a farm (figure 1.10).

Some young workers might rebel against being told what to wear to work. Wearing the latest fashions does not make them a better farmworker. Dressing safely makes them a smart worker because it increases their chances of avoiding injury or death on the job.

They should know what each job requires and dress accordingly. Ask employers or parents if specific work dress is expected. Keep these suggestions in mind:

- Wear snug-fitting clothes in good repair. Loose clothes and those with dangling threads, ripped sleeves and cuffs, and drawstrings can be caught in machinery or snag on tractor parts.
- Leave jewelry at home. Jewelry can be caught in machine parts or snagged on the tractor as when mounting or dismounting.
- Wear hard shoes with slip-resistant treads. Sandals or sneakers offer little protection from livestock trampling, briars, nails, welding sparks, falling objects, or other hazards. Ask if steel-toed work boots are necessary.
- Tie shoes snugly. Loose shoestrings can be caught in rotating parts.
- Tie long hair out of the way. Tying or covering long hair will prevent the hair from being pulled into turning parts of machinery and prevent serious injury.
- Wear long pants, the correct length and in good repair to protect legs from sunburn, splinters, briars, and thistles. Sloppy-fitting clothes can easily become entangled in machinery or snagged on tractor parts.
- Overexposure to the sun is a serious hazard. A long-sleeved shirt, a hat covering the ears and neck, and sunscreen or sunblock are all part of safe dressing in warm weather.

Dressing properly for the job is the first step in preparing to work safely.

Personal Protective Equipment

Introduction

Personal protective equipment (PPE) is designed to protect the wearer from injury and illness. Use PPE to protect the head, eyes, ears, lungs, body, and feet. PPE is the last line of defense against workplace injuries ranging from bruised toes to the loss of an eye or even death from being struck on the head by a falling object.

This section illustrates the symbols that show the need for this equipment. These symbols may appear on warning decals and safety instruction sheets.

Eye Protection

Flying objects, chemicals, dust, and crop debris can all be eye hazards in agricultural work. Always use eye wear approved by the American National Standards Institute (ANSI).

Eye protection (figures 1.11–1.13) may involve safety glasses, goggles, chemical goggles, or face shields. Protection from the front and side must be considered. High-impact hazards require different protection than splash hazards.

Prepare to work safely by using recommended personal protective equipment (PPE) for the job.

Figure 1.11 Industrial safety glasses are recommended when you see this symbol. They protect against flying and pointed projectiles and may come with brow and side-protection panels. Credit: Association of Equipment Manufacturers.

Figure 1.12 Goggles with impact-resistant lenses are recommended when you see this symbol. Goggles protect against splashes from all types of hazardous liquids. Credit: Association of Equipment Manufacturers.

Figure 1.13 Face shields are recommended when you see this symbol. They protect against splashing and crop debris, but are not designed for high-impact hazards (projectiles). Use industrial safety glasses under the face shield for complete protection. Credit: Association of Equipment Manufacturers.

Respiratory Protection

Protection of the lungs (figure 1.14) is vital to health. Agricultural work exposes workers to **vapors**, fumes, and dust. Use a respirator certified by the National Institute for Occupational Safety and Health (NIOSH) (figure 1.15). Older devices are identified with a "TC" number written on the respirator (e.g., TC-23). Newer respiratory protection devices are identified with N95, N99, or N99.97, representing the percentage of particles trapped by the filter.

Respirators are either air purifying or air supplying. Air-purifying respirators filter dust, vapors, and fumes out of the air. A single-strap dust mask is not an approved respirator and offers little breathing protection.

Firefighters wear air-supplying respirators when fighting fires. These devices are not practical for youth working on farms.

Dust masks are different from cartridge masks. Match the filter mask to the job. If assigned to a job requiring a respirator, ask for guidance.

Head Protection

Working in low-ceilinged spaces where head bumps may occur require a bump cap. If someone is working higher, a hard hat (figure 1.16) is needed. Bump caps and hard hats certified by the American National Standards Institute (ANSI)-will be marked with an ANSI code number.

Hearing Protection

Exposure to noise levels varies with jobs and activities. Sound level is measured in decibels. Normal conversation measures 60 decibels (dB), and a jet airplane at takeoff measures over 120 dB. Prolonged exposure

Figure 1.14 A NIOSH-approved dust mask is recommended when you see this symbol. An approved dust mask will always have two straps. Make sure that the mask fits snugly around your mouth and nose. Credit: Association of Equipment Manufacturers.

Figure 1.15 A cartridge-type mask is recommended when you see this symbol. Air purification from chemical fumes or vapors is necessary. Specific cartridges must be used, and the mask must fit snugly. Eye protection may be needed as well. Credit: Association of Equipment Manufacturers.

Figure 1.16 When you see this symbol, hard hats are required. Credit: Association of Equipment Manufacturers.

to loud noises leads to hearing loss. ***Hearing loss is permanent. People with hearing loss may require a hearing aid.*** Protect hearing with ANSI-approved ear protection devices.

Ear plugs and acoustic muff-style protective devices are two types of hearing protection. Ear plugs fit into the ear, while acoustic earmuffs (figure 1.17) fit over the ear itself. The preferred ear protection device covers the ear and ear canal.

Figure 1.17 Hearing protection is recommended when you see this symbol. If you cannot hear a person standing 3 feet away talking in a normal voice, hearing protection is needed. Credit: Association of Equipment Manufacturers.

Never stuff cotton into the ears to reduce noise level because cotton does not stop noise.

Protective Clothing

Steel-toed shoes (figure 1.18) or boots with steel shanks are recommended for working with a chain saw and logs, cattle and horses, lumber and concrete blocks, barrels, or 55-gallon drums, among other farm tasks.

Many tasks on the farm require hand protection (figure 1.19). Leather gloves are for handling rough or abrasive materials. Neoprene, nitrile, rubber, or barrier-laminate gloves should be used for handling chemicals and **solvents** (leather does not resist chemicals).

Figure 1.18 Steel-toed shoes or boots with steel shanks are recommended when you see this symbol. Working with a chain saw and logs, cattle and horses, lumber and concrete blocks, barrels, or 55-gallon drums are a few farm tasks that require foot protection. Credit: Association of Equipment Manufacturers.

Figure 1.19 Hand protection is recommended when you see this symbol. Leather gloves are for handling rough or abrasive materials. Neoprene, nitrile, rubber, or barrier-laminate gloves should be used for handling chemicals and solvents (leather does not resist chemicals). Credit: Association of Equipment Manufacturers.

During farm work, all clothing should fit well, and ties and strings should not dangle. Shirttails should be tucked in, jackets should be zipped or buttoned, and drawstrings should be removed from clothing.

Hazard Warning Signs

Standardized safety signs promote and improve personal safety in agricultural workplaces. Signal words, sign format, and color combinations all play a role in safety signs.

This section discusses hazard warning signs (figures 1.20–1.29) that farmworkers should observe and understand. Before operating a new piece of machinery, or one used infrequently, refer to the owner's manual for specific safety alert signs and symbols.

Figure 1.20 This symbol was created to draw attention to the need for safety. The symbol means: Attention! Be Alert! Your safety is at stake! Credit: J. Mathison.

The safety alert symbol is used with agricultural, construction, and industrial equipment. This symbol is used primarily in owner's manuals and on hazard warning signs.

Effective hazard warning signs:

- include the "safety alert" symbol.
- warn about the nature and degree of hazard or potential hazard.
- provide recommended safety precautions or evasive actions to take.
- provide other directions to eliminate or reduce the hazard.

Pictorial hazard warning signs provide safety alerts to readers and nonreaders of any language.

A pictorial quickly presents a potential hazard situation and a possible result of ignoring this potential danger. When people see these picture messages, they should ask, "What is the worst thing that can happen?"

Here are a few sample signs:

Figure 1.21 DANGER—These signs are RED and illustrate the most serious potential hazards. Credit: J. Mathison.

Figure 1.22 WARNING—These signs are ORANGE and show a lesser degree of potential hazard. Credit: J. Mathison.

Figure 1.23 CAUTION—These signs usually are YELLOW and indicate a need to follow safety instructions. Credit: J. Mathison.

Figure 1.24 Potential crushing hazard to hands. Credit: J. Mathison.

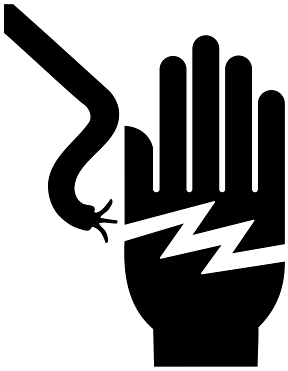


Figure 1.25 Potential electric shock hazard. Credit: Association of Equipment Manufacturers.

Figure 1.26 No riders on tractors. Credit: Association of Equipment Manufacturers.

A pictorial is a graphical representation intended to convey a message without using words. It may represent:

- hazards
- hazardous situations
- precautions to avoid a hazard
- results of not avoiding a hazard
- a combination of these messages

Pictorials may be used in addition to or in place of a word message. The pictorial should quickly help a person recognize a hazard. Learn what each pictorial shown here communicates to learn to respond to or avoid a serious injury.

Pictorials present the potential hazard, as well as the consequences of ignoring the hazard warning.

Figure 1.27 Caution: Hot surface. Credit: Association of Equipment Manufacturers.

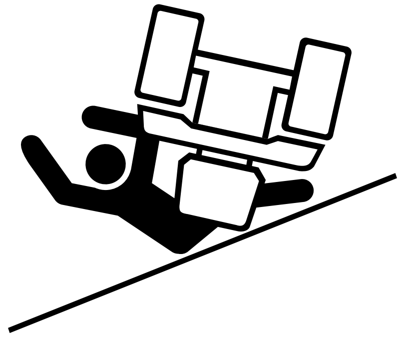


Figure 1.28 ATV rollover hazard symbol. Credit: Association of Equipment Manufacturers.

Figure 1.29 Caution: Hot fluid under pressure. Credit: Association of Equipment Manufacturers.

Hand Signals

Many farm chores seem to require shouting and hand-waving. Noise from machinery and/or distance between workers often leads to a communication breakdown. An increased risk for hazardous situations can occur.

This section presents some standard hand signals adopted by the American Society of Agricultural and Biological Engineers (ASABE). Memorize and use these hand signals. Teach them to others to save time and establish safe communications.

For more information about hand signals, including additional signals and videos of the signals in use, see **articles.extension.org/pages/62262/use-of-hand-signals-in-production-agriculture**.

Remember youth under age 14 should not operate tractors or machinery, and youth ages 14 and 15 should do so only after receiving specialized training and certification from an approved tractor and farm machinery safety program (e.g., National Safe Tractor and Machinery Operation Program, **nstmop.psu.edu**.)

Hand signals provide standard communication to all workers.

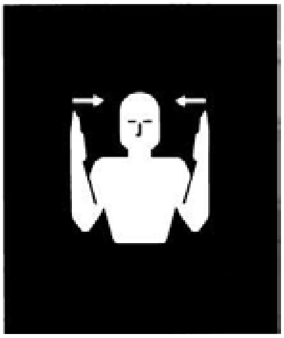


Figure 1.30 This far to go. Place palms at ear level facing head and move inward to show remaining distance to go. **Example:** Use this signal to assist a tractor operator in backing a loaded wagon or hitching to a wagon.

Figure 1.31 Come to me. Raise the arm vertically overhead, palm to the front, and rotate in large horizontal circles. **Example:** You have opened the gate for the tractor to be brought forward and you're out of the way.

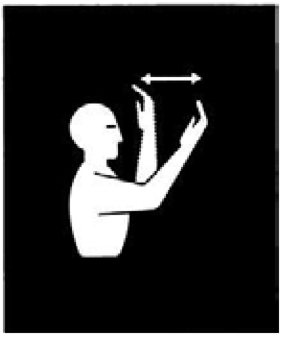


Figure 1.32 Move toward me—follow me. Face the desired direction of movement; hold the arm extended to the rear; then swing the arm overhead and forward in the direction of desired movement until the arm is horizontal with palm down. **Example:** You have hitched the machine for the operator and connected the PTO. After you are out from between the tractor and the implement, signal the operator to move out for field work.

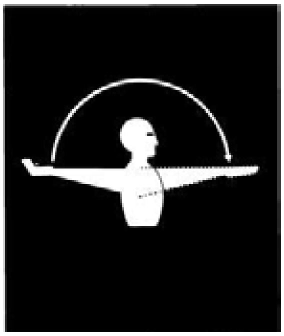


Figure 1.33 Move out—take off. Face the desired direction of movement; hold the arm extended to the rear; then swing the arm overhead and forward in the direction of desired movement until the arm is horizontal with palm down. **Example:** You have hitched the machine for the operator and connected the PTO. After you are out from between the tractor and the implement, signal the operator to move out for field work.

Figure 1.34 Stop. Place palms at ear level facing head and move inward to show remaining distance to go. **Example:** The tractor and forage wagon are now positioned for unloading into the silage blower. You signal the operator to stop.

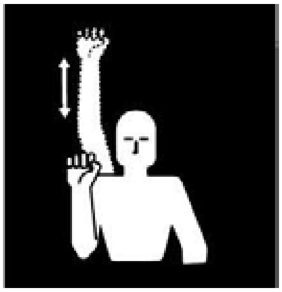


Figure 1.35 Increase speed. Raise the hand to the shoulder, fist closed; thrust the fist upward to the full extent of the arm and back to the shoulder rapidly several times. **Example:** Move the tractor out now; the way is clear.

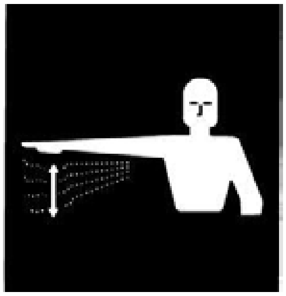


Figure 1.36 Decrease speed. Extend arm horizontally sideward with palm down; wave arm downward to 45-degree minimum several times. Do not move arm above horizontal. **Example:** You are going too fast; slow down.

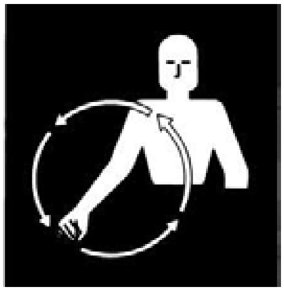


Figure 1.37 Start the engine. Move arm in circular motion at waist level to simulate cranking engine. **Example:** You need to signal the operator to start the tractor engine.

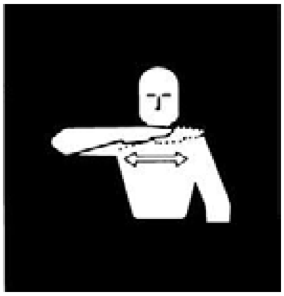


Figure 1.38 Stop the engine. Draw right hand, palm down, across the neck in a "throat-cutting" motion left to right. **Example:** You need the operator to stop the tractor engine.

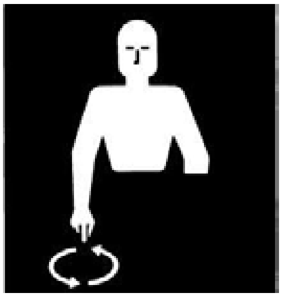


Figure 1.39 Lower the equipment. Use circular motion with either hand pointing to the ground. **Example:** Use this signal to have operator lower high lift or machine header.

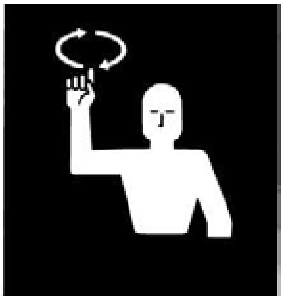


Figure 1.40 Raise the equipment. Make circular motion with either hand at head level. **Example:** Use this signal to have operator raise high lift or machine header.

Figures from ASABE. ANSI/ASAE S351. Hand Signals for Use in Agriculture. St. Joseph, MI.

Bending, Lifting, and Climbing

Bending, lifting, and climbing typically account for more than half of workplace injuries[5]. These processes are easily made safer with just a little education and forethought. Follow these tips from the National Children's Center for Rural and Agricultural Safety and Health (**cultivatesafety.org/bending-lifting-and-climbing**):

Bending

- Avoid loose clothing and clothes with strings, and tie back long hair.
- Perform warm-up exercises.
- Bend safely, using these steps:
  1. Maintain good back posture; raise and lower body with legs.
  2. Stand with feet shoulder-width apart, one foot slightly in front of the other.
  3. Keep back straight, hold in stomach muscles.
  4. Move down to a squatting position using the leg muscles.
  5. Shift from leg to leg when squatting, keeping body balanced.
  6. Keep body straight; turn feet and arms, not back, to reach for objects.
  7. Do not stay in any one position for more than a few minutes.
  8. If lifting is included in task, use proper lifting techniques.

[5] 2015 Nonfatal Occupational Injuries and Illnesses: Cases with days away from work. U.S. Bureau of Labor Statistics. https://www.bls.gov/iif/oshwc/osh/case/osch0058.pdf

Lifting

- Avoid loose clothing and clothes with strings, and tie back long hair.
- Perform warm-up exercises.
- Determine the object weighs less than 25% of body weight; can carry without straining.
- Access object without obstruction.
- Lift objects safely, using these steps:
  1. Stand close to the object.
  2. Spread feet wide to straddle the object.
  3. Squat, bending knees and hips.
  4. Keep head up and the back straight.
  5. Hold in stomach muscles.
  6. Lift using leg muscles, slowly and steadily.
  7. Keep the load close to body.
  8. Turn feet, not back, in the desired direction.

Climbing

- Avoid loose clothing and clothes with strings, and tie back long hair.
- Perform warm-up exercises.
- Climb safely, using these steps:
  1. Check the ladder is safely set.
  2. Grasp alternate rungs and take first step.
  3. Pause and make certain the ladder feels stable.
  4. Climb up, keeping feet and hips within sides of ladder frame.
  5. Always maintain three contact points, for example, two hands and one foot.

6. Keep head up and back straight.
7. Concentrate on the climbing process.
8. Do not climb beyond the third rung from the top.

See the videos at **cultivatesafety.org/bending-lifting-and-climbing**.

Safety for Farm Visitors[6]

Nonfarm families visiting a farm may not know the dangers around the farm. Establish and enforce rules for visitors around animals, chemicals, and equipment. Supervision is especially important for visiting children. Model safe behavior at all times, and never allow extra riders on tractors or ATVs.

Summary

Follow these safety suggestions to avoid becoming a farm injury or fatality statistic.

1. Identify agricultural hazards in work areas.
2. Develop a plan to deal with the hazards identified.
3. Use safety practices all the time.
4. Consider the consequences of actions before taking a chance.
5. Reinforce safe work habits by helping others work safely.
6. Wear personal protective equipment suggested for the job.
7. Speak up for safety on the job.

[6] Adapted from Progressive Agriculture Safety Day 2016. **http://www.progressiveag.org/whatwedo.cgi.**

Being safe is largely a matter of choice.

Farm Safety Apps

A number of safety apps for smartphones are now available, and more are in development. Investigate some of these to see how they could be used in activities throughout this curriculum.

- ¡Protejase!: Penn State University. Designed to increase use of personal protective equipment among Mexican and Mexican-American farmworkers imedicalapps.**com/2016/02/protejase-protect-yourself-farmworker-app/**.
- Heat Safety Tool. Occupational Safety and Health Administration. Raise awareness of heat illness among outdoor workers. **osha.gov/SLTC/heatillness/heat_index/heat_app.html**.
- Decibel 10th: SkyPaw Co., Ltd. This app turns a mobile device into a sound meter. **skypaw.com/decibel10.html**.
- Sound Meter. Smart Tools Co. Easy to use sound meter that measures SPL (sound pressure level) in decibels (dB). (Android devices). **play.google.com/store/apps/details?id=kr.sira.sound**.
- Machinery Sizing. Kansas State University. Quickly estimate tractor horsepower to pull various implements. **play.google.com/store/apps/details?id=com.jsdvorak.machinerysizing&hl=en**.

ACTIVITY 1.1

Factors Affecting Farm Safety

LEADER NOTES

Skill Level: Beginner through advanced

Ages: 8–18

Learner Outcomes: Understand why farm work tends to be dangerous and why people take risks

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee;

CRP.02. Apply appropriate academic and technical skills;

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–3 below and can summarize why farm work tends to be dangerous and why people take risks.

Life Skills: Empathy, analysis

Tags: Farm safety, risk, risk perception

Time Needed: 45 minutes

Materials List

- copies of Let's Do It! (with tables of factors that influence farm work and risk of injury (1 copy per youth)
- pens/pencils
- computer(s) with internet connectivity (for variation on part 3)

Space: Classroom or other indoor space

Suggested Group Size: Maximum of 10; could have youth discuss in groups of two or three

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: See the Variations section below to decide how you want to present the activities.

Variations: For part 1: Show the factors tables to one or two area farmers and have them identify how many factors may have contributed to an injury to themselves or someone on their farm.

For part 3: Read about one or more recent local farm accident stories. Have youth write about the hazards and how to avoid.

Introduction: Farm work is different from most other jobs. Many of these differences increase the chance that you will get hurt. Farming takes place on land that is flat for miles around, but also on land that can be hilly or mountainous. Some farming occurs where there are buildings that protect against the cold, wind, and rain, but most takes place where there is little or no shelter from the weather.

All these differences make it difficult to find easy ways to reduce your chance of injury. However, constantly thinking about what can go wrong and preparing to avoid danger will help you avoid getting hurt.

Four characteristics of farming make it different from other types of work environments:

1. A lack of uniformity and control of workplaces and work activities
2. An overlap of home and work sites
3. Operation of most farms by family members using labor without age-related restrictions
4. Little government regulation of work hazards and risk (except with pesticides)

The combined effect of these four characteristics helps make farming one of the most hazardous occupations. Factors that influence farm work and risk of injury include:

- environmental
- personal
- work activity
- social, economic, and political

Opening Questions: Why is farm work dangerous? Why do farmers and farmworkers take risks and expose themselves to safety hazards?

LET'S DO IT!

Activity 1.1

Factors Affecting Farm Safety

1. Review the list of factors **that influence farm work and risk of injury**. How many of these characteristics and factors are present on the farms/ranches where you live or work? Discuss these with your partner or the group.

Environmental factors that influence farm work and risk of injury	
Weather	Farm work must often be completed regardless of weather extremes.
Work sites	Commonly overlap with residence.
Emergency services	Not readily available; often involves a delayed response due to isolation of work site.
Isolation of work	Coworkers often not in eyesight or hearing distance when trouble occurs.
Personal hygiene	Often required and made available in other occupations. Up to individual workers in agriculture.
Environmental hazards (noise, vibration, lighting, dust, etc.)	Hazards and exposures are not monitored or regulated in agriculture as they are in most hazardous industries.

Personal factors that influence farm work and risk of injury	
Young workers	Children younger than 16 years old, and as young as 5, are commonly exposed to and interact with work hazards and environments that are beyond their normal physical, mental, and/or emotional abilities to respond to safely.
Senior workers	There is no standard retirement age in agriculture. This results in farmers with significant physical limitations and slow reaction times who continue to work in high-risk situations.
Minimal physical limits	Initial physical exams or minimum performance requirements are often required to begin work or to continue work in other hazardous occupations.
Physical exams	Routine medical surveillance is not common.
Special care for physical or mental conditions	Special care is not available or only by self-imposed restrictions. These issues are tightly controlled in other hazardous occupations.
Transfers to light duty	Transfer of workers to light duty is usually not an option in agriculture.
Dispersion of workforce	Geographic dispersion and mobility of the workforce makes providing health and safety services difficult.
Farm operators	The farm population ranges from those with advanced college degrees to those with a high school education or less; from farming full-time and working significant hours on the farm; to working full-time off the farm and farming for supplemental income; to farming only as a hobby or lifestyle statement.

Work activity factors that influence farm work and risk of injury	
Work hours	60- to 80-hour workweeks (seven days per week and 10–12 hours per day) are common hours of labor in agriculture.
Labor and management functions	These jobs represent separate functions in other hazardous occupations, but not in farming.
Work pace	The work pace can be highly erratic rather than steady, and is frequently affected by weather situations and machinery breakdowns.
Work routine	The work routine can be highly irregular, with many tasks being seasonal or done once or twice per season or year.
Specialization	Specialization is not normally possible; the phrase “jack-of-all-trades” often applies.
Instructions	Farmers often learn their trade by observation and experience.
Holidays and vacations	Days off are normal for most occupations, but not for the farmworker.
Labor demands	Farmers frequently make use of any temporarily available labor: migrant, spouse, children, friends, visitors, new acquaintances, and off-the-street employees.
Uncertainty	Farming is characterized by an uncertain future. Weather, fast-spreading plant and animal disease, broad economic policy, and unexpected world events can result in financial hardship for the farmer.
Agriculture production	There are great differences in size and type of farms, and the technology used. This makes grouping the types of modern agriculture difficult.

Social, economic, and political factors that influence farm work and risk of injury	
Lifestyle vs. occupation	Farming is commonly viewed as a "way of life" rather than an occupation.
Agrarianism	This is a term applied to agriculture that says farmers are owed a debt by society because they suffer so that a democratic society can prosper.
Day care for small children	Often not available, practical, or affordable in rural areas. Results in parents baby-sitting infants, toddlers, preschoolers, and other children during farm work.
Occupational safety and health legislation	New standards and regulations often exempt production agriculture because of a combination of lack of practicality to farming, lack of ability to enforce the standards or regulations, and the burden on farmers to comply.
Cultural beliefs about farm safety and health	There is a cultural belief that farming is a hazardous and unpredictable occupation. This contributes to the belief by farmworkers that little can be done about farm safety and health except to be careful.
Market forces	Farmers do not set their own prices for products produced. They cannot add the costs of safety and health to products to recoup losses.
Self-reliance for safety	Farmers primarily rely on their own knowledge and awareness of hazards to work safely, and often accept blame when an injury occurs, especially when they commit an unsafe behavior that directly results in an injury.
Enculturation	Children learn values, responsibility, good work ethics, decision making, and about life and death. Strong bonds among children, parents, grandparents, neighbors, and communities are developed and nourished from the shared experiences of farming.

2. How many of these factors might be present in non-farm work environments? Are there any occupations with high numbers of serious injuries that have as many of these factors as farming? Discuss with your partner or the group.

3. Make a list of farm tasks you've completed. Describe any safety hazards for each task and the reasons from the table above why these hazards were accepted.

Terms

Using what you learned above, define the following terms in your own words.

Mechanical hazard:____

____

Probability:____

____

Risk:____

____

Risk perception:____

____

Apply

Describe ways to reduce the hazards encountered in part 3 above.

Reference

Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More

Penn State Farm Safety: **extension.psu.edu/business/ag-safety**

Ag Youth Work Guidelines from the National Children's Center for Rural and Agricultural Health and Safety: **cultivatesafety.org/work**

Farm Safety, USDA, National Institute of Food and Agriculture: **nifa.usda.gov/program/farm-safety**

ACTIVITY 1.2

Risk Perception

LEADER NOTES

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Understand levels and probability of risk. Understand that human reaction time does not allow us to "beat" machines.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Student completes parts 1–4 and can summarize levels of risk. Student understands basic risk probability and the limits of human reaction time.

Life Skills: Writing, analyzing, experimenting, observing, calculating

Tags: Risk, risk perception

Time Needed: 1 hour

Materials List:

- copies of Let's Do It!
- pens/pencils
- computer(s) with internet connectivity (for variation on part 4)

Space: Classroom; farm site

Suggested Group Size: Maximum of 10; could have students discuss in groups of two or three

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange a tour with a local farm. Try to find the type of farm common in your area, so the hazards are generally applicable to the type of farm where youth in your group may live or work. If you can't identify a farm to tour in person, find links to farm tours similar to those in your area on YouTube or other internet site.

Introduction: See the Risk Perception section in chapter 1.

Opening Questions: Why do people take risks? How comfortable are you with risk? How has your past experience influenced your likelihood of taking risks? How does risk-taking affect your chances of injury?

LET'S DO IT!

Activity 1.2

Risk Perception

1. Write a paragraph or two about a time or event in which you took a risk. Next, think about the situation you described. How do you feel about the incident now? Discuss with a partner or the group.

2. Make a list of risk-taking situations you have experienced. Place these examples in the appropriate category on the risk matrix table below. Discuss your results with a partner or the group. How could you change your behavior to be safer?

Table 1.1. Applying a risk matrix table to reduce risk probability

	Severity	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequency	Frequent (A)	Shut down immediately; correct problem	Shut down immediately; correct problem	Correct ASAP	Correct sometime
	Probable (B)	Shut down immediately; correct problem	Correct ASAP	Correct soon	Correct sometime
	Occasional (C)	Correct ASAP	Correct soon	Correct sometime	Correct sometime
	Remote (D)	Correct sometime	Correct sometime	Correct sometime	Correct sometime
	Improbable (E)	Correct with preventive maintenance	Correct with preventive maintenance	Correct with preventive maintenance	Correct with preventive maintenance

3. Some people are more prone to taking risks than others. Based on your work in parts 1 and 2 above and your discussions with others about their answers to those parts, do you think you are more or less likely than others to take risks? If you think you are more likely to take risks, doing the following is even more important:

   - Read the operator's manual or get trained by an experienced user before using equipment.
   - Follow suggested caution warnings and safety gear recommendations.
   - Make sure to perform only age-appropriate tasks using age-appropriate equipment (see Activity 0.1).

4. Take a safety tour of a farm. List the hazards and the chores you find risky. Identify potential hazards for each chore that must be done on this farm. Identify ways you could stay safe while performing these chores.

Apply: If you live or work on a farm, or may in the future, repeat the activities in part 4 for that type of farm.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 1.3

Mechanical Hazards

LEADER NOTES

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Understand what mechanical hazards are, where they are typically located, and how to protect against them.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Student completes parts 1 and 2 below and can summarize what mechanical hazards are, where they are typically located, and how to protect against them.

Life Skills: Analysis

Tags: Burn point, crush point, mechanical hazards, pinch point, pull-in point, shear point, wrap point

Time Needed: 1 to 1.5 hours, depending on the amount of machinery available

Materials List:

- at least one piece of agricultural machinery or equipment
- safety glasses for each person
- gloves for each person
- other safety gear as dictated by the equipment to be examined
- copies of Let's Do It
- pens/pencils

Space: Preferably a barn or agricultural equipment shed

Suggested Group Size: Maximum of 10; could have students explore machines in groups of two or three

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange to have at least one agricultural machine available on which the students can identify mechanical hazards. Plan to operate the machinery to demonstrate safety. (See question 2 under "Let's Do It!") The best-case scenario would include an old and new version of the same machine, and to have multiple types of machinery.

Introduction: See the Mechanical Hazards section in chapter 1.

Opening Questions: What are some of the most dangerous pieces of farm equipment? What makes them dangerous? How can you protect yourself from these dangers and use this equipment safely?

LET'S DO IT!

Activity 1.3

Mechanical Hazards

1. Write each word next to its definition.

pinch point	shear point	burn point
freewheeling part	crush point	wrap point
pull-in point	stored energy	thrown objects

Definition	Mechanical Hazard
1. Hot mufflers, engine blocks, pipes, and fluids (fuel, oils, chemicals) are all examples of this type of hazard on tractors, self-propelled machinery, and pulled machinery.	
2. A hazard formed when two machine parts move together and at least one of the parts moves in a circle.	
3. This type of hazard occurs when machine parts continue to move after the power to the machine is turned off.	
4. Any type of rotating machine component can be considered this type of hazard.	
5. These types of hazards occur when a machine discharges materials into its surrounding environment.	
6. A hazard formed when the edges of two objects move across or close enough to each other to cut a relatively soft material.	
7. These hazards are caused by energy that is confined and then released.	
8. A hazard formed when two objects are moving toward each other or when one object is moving toward a stationary object, and the gap between the two is decreasing.	
9. Rotating parts that come in close contact with each other, such as feed rolls, often form these points. They can also be formed by moving components, such as feed chambers on square balers.	

2. Without turning on the agricultural equipment provided, identify the mechanical hazards involved in using each machine. Discuss how the hazard is created and how each can be avoided. Then, your leader or other facilitator will turn on and operate each machine, review the hazards, and demonstrate safe operation.

Terms and Concept Discovery: Use the information in part 1 above to think of an agricultural machinery example for each hazard.

Burn point:____

____

Crush point:____

____

Freewheeling part: ____________________________________

____

Pinch point:____

____

Pull-in point:_______________________________________

____

Shear point:____

____

Stored energy:______________________________________

____

Thrown objects:_____________________________________

____

Wrap point:____

____

Apply:

Think about other types of agricultural equipment not shown in this activity. Using what you've learned about the general types of mechanical hazards, identify the hazards involved when operating each machine. Identify safety gear needed and safe operating procedures.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 1.4

Reaction Time

LEADER NOTES

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Understand that human reaction time does not allow us to "beat" machines.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes reaction time math problems, understands the limits of human reaction time, and how to stay safe around mechanical hazards on the farm.

Life Skills: Experimenting, observing, calculating, analyzing

Tags: Reaction time

Time Needed: 1 hour

Materials List:

- pens/pencils
- copies of Let's Do It!
- stopwatch or smartphone stopwatch app
- calculator(s) (optional)

Space: Classroom; farm site

Suggested Group Size: Maximum of 10; could have youth discuss in groups of two or three

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange access to several types of electric motors, including hand tools, kitchen appliances, and farm tools.

Introduction: See the Reaction Time section in chapter 1.

Opening Questions: How quickly can you react? Do you think you are faster than a machine? Have you ever tested this? How could you test it?

LET'S DO IT!

Activity 1.4

Reaction Time

1. Conduct a survey of electric motors on machines and small appliances (drills, portable saws, etc.) and create a chart of the motor speed in rotations per minute (rpm). The speed of the motor in rpm is found on the motor nameplate. You can also survey electric motors in the farm shop or in your home for any electrical appliance where you can view the electric motor nameplate information. Here's an example:

Motor/Machine	Speed of Motor in rpm
Table saw	1,740

2. Using a stopwatch or a smartphone app, press the start button to start the timer, and as quickly as possible, press the stop button. See how fast you can do this simple task. Take several readings, record the results, and calculate the average time you needed to stop the timer. Although this is not a measure of reaction time to an emergency, you can use this measurement to make reaction time calculations in the following questions.

   Time it took you to start/stop the stopwatch: ____________ seconds/fractions of a second

3. Solve this reaction-time math problem.

   A drill press is rotating at 1,800 rpm. If your reaction time is ½ second (0.5), how many revolutions of the drill press will occur before you react and pull your shirt sleeve away?

   _______________ revolutions before reaction to pull away.

   Hint 1: Convert rpm to revolutions per second (RPS).

   Hint 2: There are 60 seconds in a minute.

   Hint 3: Multiply RPS from hint 1 by your reaction time in part 2, or use ½ second reaction time.

4. A PTO shaft is a rotating part at the rear of a tractor that transfers power from the tractor to PTO-powered machinery such as a hay baler. Let's say a PTO turns 540 rpm. Your reaction time is ½ second. If your shoelace is caught in the shaft, how many turns of the PTO shaft would occur before you react? Use the hints from question 3.

   _______________ revolutions before reaction to pull away.

5. Make the same calculation as in question 4, but use a 1,000 rpm PTO shaft.

   ______________ revolutions before reaction to pull away.

Terms and Concept Discovery: Using what you learned above, define the following term in your own words.

Reaction time:

____

Apply: What do your answers to the reaction time math problems mean for your safety?

____

____

How can you protect yourself from the dangers of rotating machinery and other mechanical hazards?

____

____

Reference: *National Safe Tractor and Machinery Operation Program, Student Manual*, 3rd ed. 2020. Penn State Extension, Ohio State University Extension, and the National Safety Council.

Learn More:

4-H Canada. Human reaction time. **bit.ly/2rRIzst**

National Ag Safety Database, Recognize limitations to avoid injury. **nasdonline.org/1275/d001079/recognize-limitations-to-avoid-injury.html**

ACTIVITY 1.5

Personal Protective Equipment

LEADER NOTES

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Understand the personal protective equipment needed for various common farm tasks and why it's important always to use it.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–3 and understands proper protective equipment for various common farm tasks and the importance of using it.

Life Skills: Memory, analysis, discussion

Tags: Personal protective equipment, safety gear, farm hazards

Time Needed: 45 minutes

Materials List:

- pens/pencils
- copies of Let's Do It!
- personal protective equipment of various kinds (optional, for variation on part 1)

- live models demonstrating unsafe clothing for farm work (optional, for variation on part 3)

Space: Classroom; farm site

Suggested Group Size: Maximum of 15 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual*, 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: See the Variations section below to decide how you want to present the activities, and prepare accordingly.

Variations: For part 1: Have samples of all personal protection equipment and demonstrate each. Ask youth to give you the name of the equipment when you hold it up.

For part 3: Have live models demonstrate unsafe clothing.

Introduction: See the Personal Protective Equipment section in chapter 1.

Opening Questions: Have you ever been injured while doing a chore for which you weren't properly protected, or do you know someone who has? Do you know anyone who's alive because they wore the appropriate safety gear for their task?

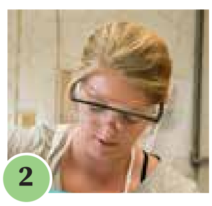
LET'S DO IT!

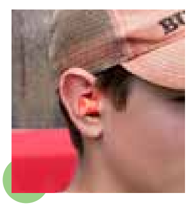
Activity 1.5

Personal Protective Equipment

1. Match the hazard with the PPE needed. There is more than one correct answer for some tasks. Additional PPE not pictured here may also be appropriate for some tasks.


1


2

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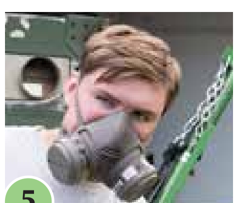
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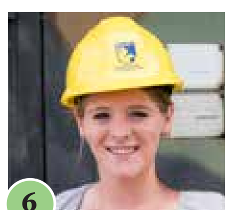
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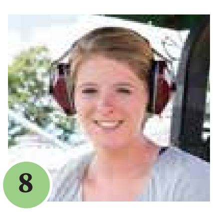
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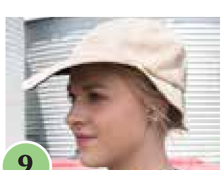

9


10

Tasks or Chores
A. Mowing grass
B. Pouring detergent to clean milking equipment
C. Grinding a broken bolt
D. Sweeping driveway
E. Working in part of an old barn with a low ceiling
F. Applying lime
G. Helping to trim branches
H. Using a grain elevator
I. Weeding
J. Spray-painting
K. Sweeping up moldy grain in grain bin

2. Name some places where you have seen PPE symbols, especially on the farm, and the symbol you've seen. Have you used the recommended safety gear for chores you've completed? If not, why not?

3. Identify at least four safety issues with the clothing in this drawing for agricultural work.

Apply: Name three specific ways you will use proper safety gear during tasks you perform on the farm.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More:

Personal protective equipment and health. Penn State Extension. **extension.psu.edu/business/ag-safety/health**

Personal protective equipment (PPE). AgriSafe Network. **agrisafe.org/ppe-training**

ACTIVITY 1.6

Safety Signs and Signals

LEADER NOTES

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Understand hazard warning signs and standard agricultural work hand signals.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–3, understands hazard warning signs and their importance, and knows how and when to use farm hand signals.

Life Skills: Memory, analysis

Tags: Safety signs, warning, caution, danger

Time Needed: 45 minutes

Materials List:

- pens/pencils
- copies of Let's Do It!
- flash cards

Space: Classroom; farm site

Suggested Group Size:

Maximum of 15 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Copy and cut out the hazard warning signs to use as flash cards.

See the Variations section below to decide how you want to present the activities.

Variations: For part 1: Bring in a variety of hazard warning signs and have the youth identify their meanings.

For part 2: Have someone demonstrate each hand signal and ask the youth to say when you would use it. Have the youth take turns making and recognizing the safety hand signals.

Introduction: See the Hazard Warning Signs and Hand Symbols sections in Chapter 1.

Opening Questions: Have you ever tried to communicate with another person during farm work by shouting over the noise of a tractor or other machine, or tried to get the attention of a coworker across a field? What's another way to communicate more effectively in these situations?

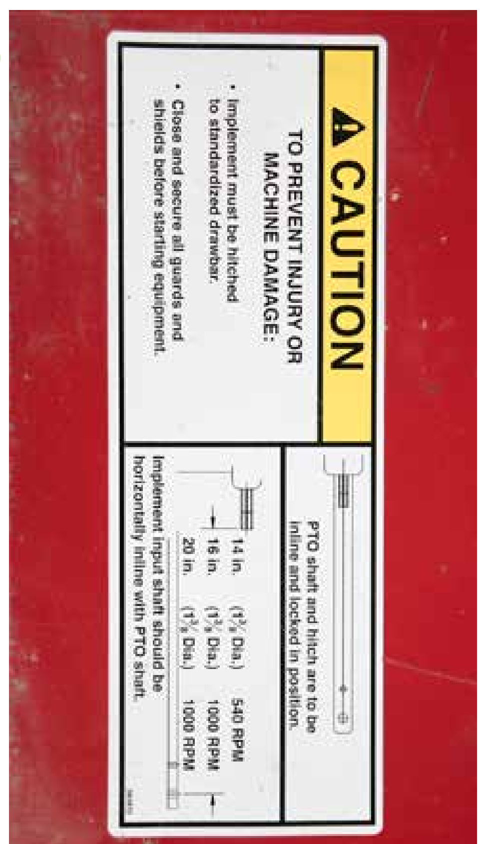
cut along dotted line to create flash cards

1

2

3

4



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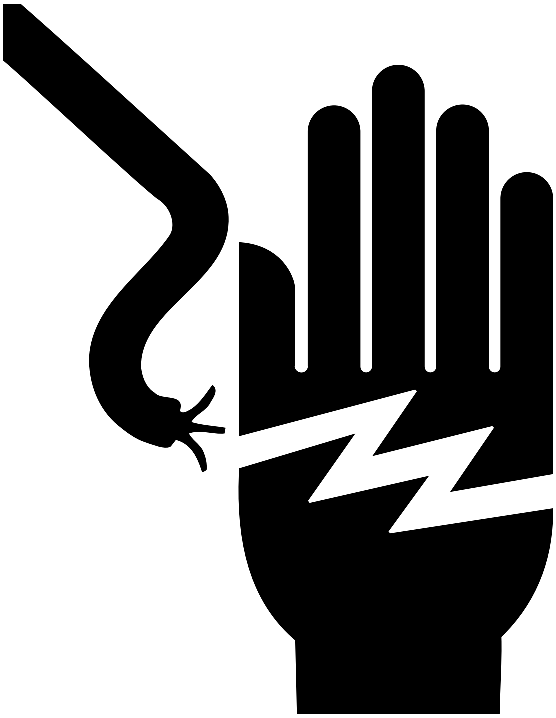

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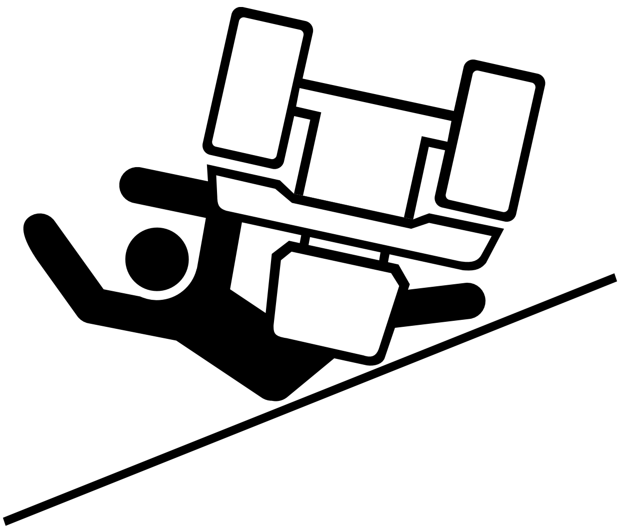

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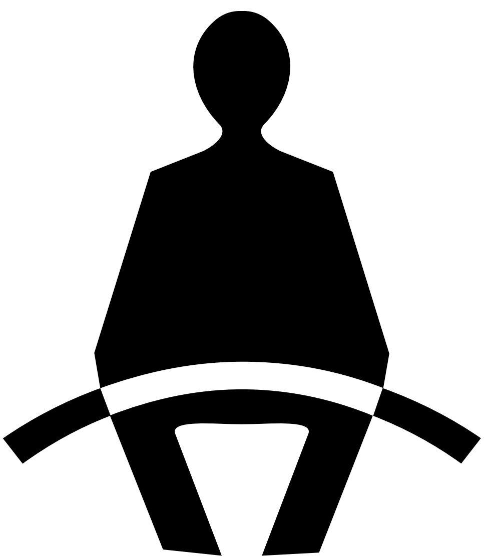

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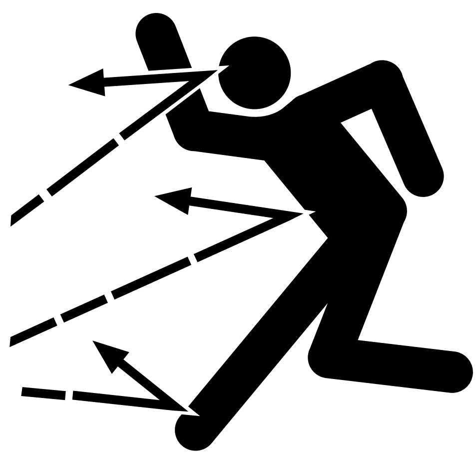
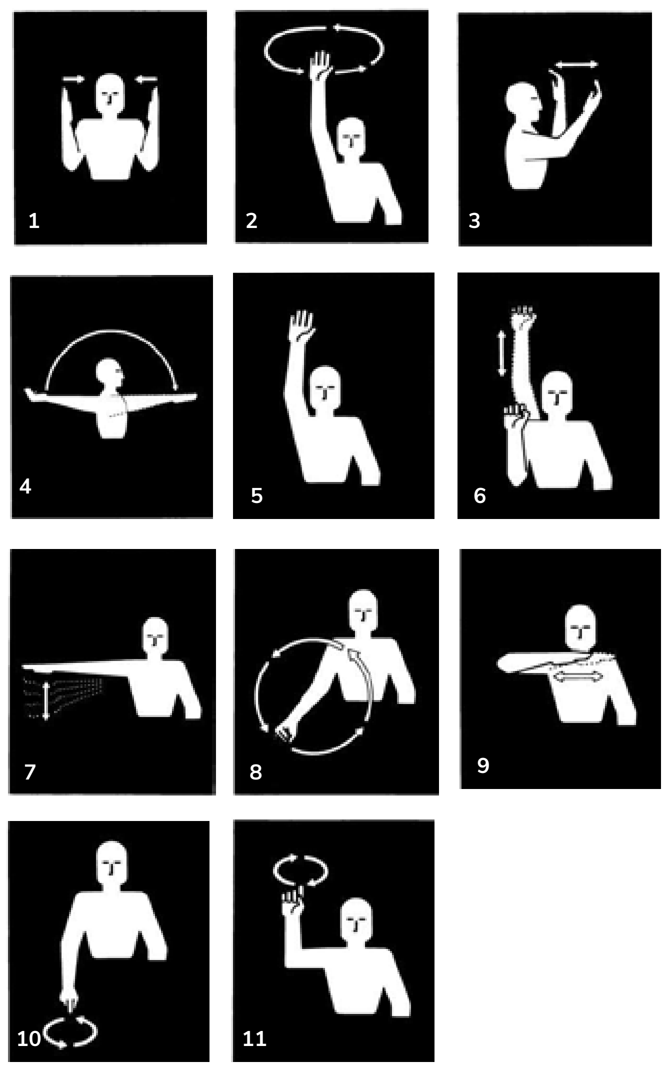


Activity 1.6

Safety Signs and Signals

1. Quiz yourself or each other on the meanings of the hazard signs provided by the group leader.
2. Match the hand signal with the meaning in the chart below.

meaning	signal
A. this far to go	
B. start the engine	
C. increase speed	
D. lower the equipment	
E. decrease speed	
F. move out—take off	
G. raise the equipment	
H. come to me	
I. move toward me—follow me	
J. stop	
K. stop the engine	



Credit: Figures from ASABE. ANSI/ASAE S351. Hand Signals for Use in Agriculture. St. Joseph, MI.

3. Name some places where you have seen hazard warning signs, especially on the farm, and the symbol you've seen.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Chapter 2 Tractors

Please see Note to Leaders at the front of this book for some important safety and logistics considerations.

The speed, power, flexibility, adaptability, and handling ease of today's tractors make them indispensable for modern-day farming. This chapter begins with a focus on agricultural tractors and what they are designed to do.

Tractor Types, Sizes, and Purposes

There is a broad array of tractors operating on farms today. Tractors can have either narrow or wide front ends, use wheels or tracks, and be two-wheel drive, four-wheel drive, or articulated. A narrow front end "tricycle" tractor will be older, because they have not been produced this way since the 1960s. **Articulated tractors** feature a frame that pivots and oscillates in the center, allowing the rear tires to follow the same path as the front tires, always keeping all four wheels on the ground. They are usually very large (at least 250 hp) and operated only by experienced farmers. Younger and less experienced tractor drivers usually operate tractors ranging from lawn- and garden-size (~20 hp) to large two- and four-wheel-drive tractors (around 150 hp).[7] Many older and smaller tractors will not have a rollover protective structure (ROPS), while most new tractors will have a ROPS and seat belt.

[7] See Youth and Tractors below for information about age-appropriate tractor sizing and job types.

Farm tractors were designed for four primary purposes:

- load mover (high lift)
- remote power source (PTO)
- implement carrier (3-point hitch)
- transport unit (drawbar unit)

Farm tractors are not recreational vehicles. Farm tractors are not to be used for fun, play, mud-bogging or racing, unless specifically modified for that purpose. Tractors must be used only for work purposes. Other uses can increase the chance of injury to the driver or others, as well as damage to the tractor, implements, and other property.

As discussed in the Introduction, farm safety demands youth are assigned age-appropriate tasks. Review that discussion in the Introduction before beginning any new farm task.

Tractor Hazards

Tractor hazards are grouped into the following categories:

- overturns
- runovers
- power takeoff entanglements
- older tractors

Overturn

Tractor overturns (figure 2.1) account for the most farm-work fatalities. Approximately 50% of tractor fatalities come from tractors turning over either sideways or backward. There are dozens of examples of tractor overturn situations. Most are preventable if drivers follow safe tractor operation practices. Some common examples of tractor overturns include:

- turning or driving too close to the edge of a bank or ditch
- driving too fast on rough roads and lanes and running or bouncing off the road or lane
- hitching somewhere other than the drawbar when pulling or towing objects
- driving a tractor straight up a steep slope
- turning a tractor sharply with a front-end loader raised high

A rollover protective structure (ROPS) is a structural steel cage designed to surround the operator. These can protect the operator from being killed when a tractor overturns, particularly when they're built into an enclosed cab. This is especially true if the operator has fastened the seat belt. Remember, a ROPS can protect from injury but cannot keep the tractor from overturning in the first place. This explains why operating a tractor safely is important even if the tractor has a ROPS.

Top-heavy, powerful tractors can upset if used improperly.

Figure 2.1 Tractors can overturn with high speed sharp turns. Avoid sudden sharp movements in all tractor work. Credit: J. Mathison.

Runover

There are three basic types of tractor *runover* incidents.

1. extra riders
2. operator falls
3. bystanders

A passenger (extra rider) on the tractor may fall off. Extra rider incidents happen because the only safe place for a person on a tractor is the operator's seat (figure 2.2). The tractors driven by young and inexperienced operators have only one seat—for the operator. When extra riders stand on the tractor drawbar, axle housing, side links of three-point hitches, rear-wheel fenders, or the area immediately around the operator's seat, they can be thrown from the tractor. Extra riders rarely keep a tight handgrip on the tractor.

Figure 2.2 Tractor runovers have claimed many lives. Extra riders can slip from the tractor and be crushed before the operator can stop. Say no to your friends who want to hitch a ride. Credit: Association of Equipment Manufacturers.

Another runover incident involves the tractor operator either falling off the tractor or being knocked out of the seat by a low-hanging tree branch or other obstacle during operation. This most often happens on older tractors with no ROPS and an older seat with no arm or back rest (often called pan seats). People can more easily lose their balance and be knocked off or bounced out of a pan seat. An operator can also be run over while trying to mount or dismount a moving tractor. This type of incident can occur when the operator leaves the tractor seat without first shutting off the tractor and setting the brake or placing it in PARK. The tractor can move unexpectedly. This may happen during the hitching and unhitching of equipment.

Shut off the tractor before dismounting for any reason.

The third type of runover incident involves a bystander—a person who is on the ground near a tractor. This includes the tractor operator who may try to start a tractor from the ground while the tractor is in gear. This usually involves an older tractor started in gear, or a newer tractor when an operator attempts to bypass the safe start-up design.

Small children, often under age 5, are sometimes run over by tractors (and equipment) as they are moved around the farmstead. Often, the tractor operator is unaware the child is near the tractor. A loud noise, such as the startup of a tractor, is often attractive to young children, and they may run toward it as it starts or begins to move.

One seat on a tractor means only the driver can ride. Keep all others away.

Power Takeoff (PTO) Entanglement

The tractor *power takeoff (PTO)* is another major hazard (figure 2.3). The PTO stub transfers power from the tractor to PTO-powered machinery. The PTO stub normally turns between 540 and 1,000 revolutions per minute. At this rate, the stub is turning 9 to 17 times per second. This is much faster than a person can react if they are caught and pulled into or around the PTO stub or shaft. A person can have an arm or leg wrapped around a PTO stub shaft before they realize they are in danger. A PTO master shield protects a person from the PTO stub. Some tractors have PTO stub guards that fasten to the PTO stub. All tractors should have a PTO master shield to protect the tractor operator and helpers.

Older Tractors

Always include *older tractors* when talking about tractor hazards (figure 2.4). Many farm tractors still used for work may be 30–40 years old or older. These older tractors are often more dangerous to operate because they do not have modern safety features. In addition, some parts of an older tractor may not have been maintained in good working condition. Safety hazards with older tractors may include:

- lack of ROPS and seat belt
- a seat without arm rests or a back (pan seat)
- a seat does not adjust easily or at all
- absence of a safety start system
- no bypass starting protection
- rear brakes and brake pedals do not operate properly
- front wheels do not turn as quickly as the steering wheel turns
- tractor has no warning flashers or the flashers do not work
- PTO master shield is missing or does not offer adequate protection

Figure 2.3 Tractors provide remote power to machinery. This turning shaft, the PTO, must be guarded to prevent entanglement hazards. The PTO shown here is unguarded and very dangerous. Credit: J. Mathison.

Young and inexperienced workers may be expected to work with older tractors for jobs such as raking hay, hauling wagons, and mowing fields or pastures. An older tractor is appropriate for those types of jobs. Young and inexperienced operators should be given newer tractors when possible.

Youth and Tractors

Farm families often provide much of the labor for the operation of the farm. Children may work on the farm to learn responsibility and contribute to the productivity of the business. Tractor operation can start early for farm youth because tractors are a large part of farm work.

This section presents a Tractor Operation Chart as a guide to appropriate work for young operators.

Examples of common jobs performed by youth operating tractors include:

- mowing pastures, fields, yards, and lanes
- raking and baling hay and straw
- towing hay and grain wagons between fields and storage
- picking rocks and other obstacles from fields using a front-end loader
- scraping manure from barn floors with a tractor-mounted blade
- using the tractor to power augers and elevators during unloading operations
- pulling old fence posts and tree stumps out of the ground with log chains

Hazards can arise during jobs involving tractor use. Often, larger tractors feature more complex operations than smaller tractors. Additionally, large and complex equipment may be attached to and powered by the tractor.

Young tractor operators do not usually have the experience needed to skillfully and safely operate large, complex combinations of tractors and machinery.

Figure 2.4 Older tractors are often assigned to younger drivers to do less heavy chores. Raking hay, pulling wagons, or hauling feed to livestock does not require the most powerful tractor. Older tractors may have safety deficiencies due to age and missing safety features. This tractor does not have a ROPS or seat belt. Credit: Central States Center for Agricultural Safety and Health.

Cultivate Safety Tractor Operation Chart

Farm injury prevention specialists from the U.S. and Canada developed a guide to tractor operations by age group as a way of matching youths' capabilities with tractor operation jobs. The chart is below.

Youth can use this chart:

- to see if they have been doing jobs with the size tractor that matches their age.
- to guide employers in determining what youth at certain ages can reasonably do with various types and sizes of tractors.

Youth are often overconfident about their ability to react safely to new or unexpected hazardous situations with tractors.

Refer to the specifc guideline for recommended supervision	Size of Tractor			
Increased Complexity of Job	LAWN & GARDEN less than 20 hp	SMALL 20 hp–70 hp	MEDIUM/LARGE more than 70 hp	ARTICULATED
OPERATING A FARM TRACTOR (no equipment attached)	12–13 years	12–13 years	14–15 years	16+ years
TRAILED IMPLEMENT fieldwork	12–13 years	12–13 years	14–15 years	16+ years
3-POINT IMPLEMENTS fieldwork	12–13 years	14–15 years	14–15 years	16+ years
REMOTE HYDRAULICS fieldwork	14–15 years	14–15 years	14–15 years	16+ years
PTO-POWERED IMPLEMENTS fieldwork	14–15 years	14–15 years	14–15 years	16+ years
TRACTOR-MOUNTED FRONT-END LOADER	14–15 years	16+ years	16+ years	16+ years
WORKING IN AN ORCHARD	14–15 years	16+ years	16+ years	16+ years
WORKING INSIDE BUILDINGS	14–15 years	16+ years	16+ years	16+ years
DRIVING ON PUBLIC ROADS*	N/A	16+ years	16+ years	16+ years
PULLING OVERSIZED OR OVERWEIGHT LOAD	**Due to increased hazard and complexity, these jobs should** not **be assigned to children.**			
HITCHING TRACTOR TO MOVE STUCK OR IMMOVABLE OBJECTS				
SIMULTANEOUS USE OF MULTIPLE VEHICLES				
ADDITIONAL PERSONS WORKING ON A TRAILING IMPLEMENT				
PESTICIDE OR ANHYDROUS AMMONIA APPLICATION*				

*Follow State/Province Laws

Tractor Instrument Panel

Instruments, or gauges, on the tractor control panel (figure 2.5) give the driver information about the operating conditions within and around the tractor. All tractor drivers should know how to read the instruments to assure proper tractor operation.

When tractor systems malfunction, continued operation may cause breakdowns that result in costly repairs and possible injury.

This section identifies and explains instruments and gauges commonly found on tractors. Tractor operation manuals and experienced tractor operators may offer additional information to clarify questions about this section. The operator's manual will provide correct, engineering-based information. The experienced operator may have personal preferences for operations that differ from the actual safety standards.

Figure 2.5 The modern tractor instrument panel may appear as complex as the cockpit controls of a jet airliner. The operator must know what each instrument or gauge is telling him/her about operating conditions. Credit: J. Mathison.

Instruments and Gauges

Instruments can include warning lights, analog gauges such as temperature, computer digital displays, buzzers, or standard gauges. The inexperienced operator should develop the habit of regularly checking the instrument panel. Gauges should be checked:

- at start up
- at regular intervals during operation
- when changes occur in the normal sounds of operation

Abnormal gauge readings, plus changes in the sound of the engine during operation, indicate a problem. Immediately **stop the engine in a safe place** and seek help from the owner or an experienced operator.

Instruments may include the following (there may be many more):

- engine speed indicator (tachometer)
- oil pressure indicator
- engine temperature indicator
- fuel gauge
- air filter condition indicator
- transmission temperature indicator
- hydraulic system oil level indicator
- hour meter
- charge indicator

Each of these instruments is important for safe tractor operation, as well as to avoid damage to the tractor. Other gauges may be found on tractors. Be sure to understand the meaning of all instruments, gauges, and warnings before operating a tractor.

Learn which warning lights, gauges, and digital displays are on tractors before operating them.

Tachometer (Engine Speed Indicator)

Tachometers show revolutions per minute (rpm). Engine rpm must match the job.

Incorrect rpm can lead to:

- engine damage
- driveline and power takeoff (PTO) damage
- hazardous situations

Low engine speed while in a higher gear while trying to pull a heavy load can stall the engine.

High engine speed with a low gear while attached to a heavy load can create enough torque (rotational force) to tip the tractor backward. Accelerating quickly with a heavy load while traveling up a slope also can cause the tractor to tip backward.

Engine rpm must also match PTO-driven machine requirements. Speed up the engine before engaging the PTO to operate an implement. Low engine speed could stall the tractor. High engine speed could shear off the implement's safety shear pin if the pin were already under load. (e.g. , a plugged hay baler).

Follow the manufacturer's recommendations for engine speed selection.

Engine speed must match the work to ensure safety and to avoid engine and driveline damage.

Charge Indicator

The charge indicator, or ammeter, shows whether the alternator or generator is charging the battery properly. Each time the tractor is started, the battery is discharged. During operation, the battery is recharged. Gauges will indicate + or – charge. Lights will show red at low charge. If the battery is discharging, find out the cause. A low battery will prevent the engine from starting.

Oil Pressure Indicator (Oil Light or Gauge)

This indicator is important to the long life of the engine. If the light or gauge shows oil pressure is low, stop the engine immediately and determine if there is an oil leak or other reason for low oil levels. Never operate the engine with low oil pressure or oil levels. Oil lubricates the internal parts of the engine and prevents major repair expense.

Engine Temperature Indicator

The engine must be cooled to prevent damage. Water-cooled engines can overheat if coolant is lost, radiators become clogged with debris, or the radiator leaks.

If the engine overheats, stop the engine, allow it to cool, then check for the cause.

Never open the radiator cap while the engine is hot. Scalding from extremely hot water can result.

Never open the radiator cap when the tractor engine is hot. Scald injury can occur.

Fuel Gauge

Check the fuel gauge before leaving for the field. Running out of fuel is inconvenient. On some tractors, running out of fuel (diesel) means time-consuming process of bleeding air from the fuel lines before the tractor will start again.

Other Gauges

Tractors may come equipped with instruments to monitor air filter conditions, transmission temperatures, hydraulic system oil levels, and hours of work (hour meter). Become familiar with all instruments before operating the tractor.

Tractor Controls

To help tractor drivers identify controls and use them correctly, many tractor manufacturers use the same color code for specific tractor controls. The direction of movement for controls has also become standardized.

Many older tractors do not have controls with uniform color coding. Sometimes those colors wear off or a control is replaced with an irregular color control knob. Moving a control not color-coded may result in unexpected operation.

This section identifies the four main groups of tractor controls, their colors, and their direction of movement. Each group of controls is discussed in more detail.

Controls and Colors

The American Society of Agricultural and Biological Engineers (ASABE) has published standards for tractor controls. (Standards are widely-accepted rules set in place by experts.) The four main groups of color-coded controls are discussed here.

Commit this color code to memory, This information is used to operate a modern tractor.

STOP ENGINE—**RED**

GROUND MOTION—**ORANGE** (engine speed, PARK-Lock, transmission)

POWER ENGAGEMENT—**YELLOW** (engage PTO or remote power sources)

POSITIONING and ADJUSTING—**BLACK** (choke the engine, turn lights on)

Remember older tractors may not use these colors, or the color may no longer be visible. If the tractor does not have color controls, take time to learn about the controls on that tractor.

A control on an older tractor may not produce the same result on a newer tractor.

Moving Controls

As a general rule, controls will function in the following way:

- To engage a foot brake, push in. To set a hand brake, pull up.
- A foot clutch is disengaged when it is pushed in and engaged when let up.
- A hand-operated engine speed control (throttle) increases the engine speed if the throttle is moved upward or forward. A foot-operated throttle increases speed as it is pushed forward or downward by toe pressure.
- The direction the tractor travels is controlled by specific forward and reverse gears or by directional controls. If a hand-operated directional control is used, the tractor moves in the same direction the control moves.
- The engine stop control is by key and by mechanical push-pull control. A key is always turned counterclockwise to stop an engine. A push-pull lever is always pulled out to stop the engine.
- Controls that lift or lower attachments or implements are generally pushed forward, down, or away for lowering, and pulled back, up, or toward the operator for lifting.
- A PTO is usually engaged when pulled up or pushed forward.

Engine Stop Controls—RED

"How do I stop the engine?" What is a routine operation on one tractor can be a little confusing on a different tractor.

For many years, tractor manufacturers have used the same color for certain controls to help drivers identify controls and use them correctly.

Red is the color code for the single purpose of the “Stop Engine” control. Whether it is a gasoline engine, a diesel engine, or an alternative fuel engine, the color red indicates a stop engine function.

Gasoline engine—Red letters on key switch.

Diesel engine—Red fuel shut-off control (figure 2.6). Most diesel engines are shut off with the fuel shut-off control, not by the ignition key.

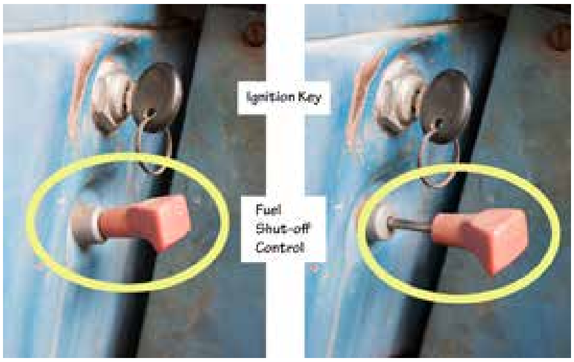


Figure 2.6 Remember, diesel engines are often shut off with the fuel shut-off control, not by the ignition key. Newer diesel engines may be shut off by the key only. Credit: J. Mathison.

Some Rules for Red Controls

If a mechanical push-pull fuel switch is used, it must:

- Be within 6 inches of the key switch.
- Be pulled to stop.
- Be labeled “Pull to Stop Engine.”
- Remain in the stop position without continued effort.

Key switch (figure 2.7) controls turn counterclockwise to stop the engine.

Some newer diesel engines are also stopped simply by turning the key counterclockwise to the off position.

A red control knob means “stop the engine.”

Figure 2.7 Key switch. Credit: J. Mathison.

A similar-colored control on an older tractor may not produce the same result as the control on a newer tractor.

Ground Motion Controls—ORANGE

“How do I get this tractor to move? How do I stop this operation?” For many years, tractor manufacturers have used the same color for certain controls (figure 2.8) to help drivers identify and use them correctly.

Figure 2.8 Ground motion controls include transmission controls, park-lock, and gear-shift levers. Credit: J. Mathison.

Orange is the color code for ground motion controls, which include:

- engine speed
- transmission controls
- parking brake or park-lock
- independent emergency brakes
- differential lock

Tractor controls can seem confusing when they are new to the operator. Ask for a demonstration of the controls and check the operator's manual to understand the job being performed. Supervisors will provide information to keep operators safe, equipment secure, and to get the job done properly. The operator's manual is the most reliable place to find engineering-based information about a tractor.

Some Rules for Orange Controls

- Engine speed controls (figure 2.9) are operated with the right hand and/or right foot.
- Transmission gearshift patterns must be clearly and permanently identified.
- Differential lock controls are engaged with a forward or downward motion.

An orange control knob shows where to control ground motion.

Power Engagement Controls—YELLOW

"How do I get this implement to run? How can I stop this machine? Where is the PTO control for this tractor?"

For many years, tractor manufacturers have used the same color for certain controls to help drivers identify and use them correctly.

Yellow is the color code for the controls that engage mechanisms using the tractor as a remote power source. The same color coding is used for self-propelled machines. Here are a few of the power engagement-type controls:

- PTO (figure 2.10). PTO controls are designed to move to the rear or downward to disengage the PTO.
- cutter heads
- feed rolls
- elevators
- winches
- unloading augers

Figure 2.9a The foot throttle on this modern tractor is orange. Orange is the color code for ground motion controls. Credit: J. Mathison.

Figure 2.9b The foot throttle on this older tractor is black. Many older tractors won't have the more modern color coding of controls. Credit: J. Mathison.

Figure 2.10 Yellow color-coded controls engage accessories. This is often done through the PTO control, an example of which is shown here. Credit: J. Mathison.

Rocker Switches

Horizontal-mounted rocker switches (figure 2.11) use the right side to begin normal machine operation.

Vertical-mounted rocker switches use the upper side of the switch to begin normal machine operation.

A yellow-colored control knob means "engage remote power" to a machine.

Figure 2.11 Rocker arm switches may be used. If you find an unfamiliar control feature, ask for instructions before operating costly equipment. Credit: J. Mathison.

Positioning and Adjusting Controls—BLACK

"Every control knob seems to be black except that red, orange, and yellow one. I want to lift the scraper blade to clean the free stall alley like the owner told me to do. Let's see, which one of these levers will I use?"

For many years, tractor manufacturers have used the same color for certain controls to help drivers identify and use them correctly.

Black is the color code for controls to position or adjust tractor work accessories. A few of the positioning/adjusting controls are:

- remote hydraulic control
- implement hitches
- unloading components on self-propelled equipment
- engine chokes and steering column position
- lights, flashers, and signals (figure 2.12)
- cab comforts (fans, radio, etc.)

Unfamiliar tractor controls may seem confusing. Ask for a demonstration of the controls to use for the assigned job. Supervisors want to keep people and equipment safe, and to get the job done properly. Check the operator's manual for the most reliable engineering-based information.

Figure 2.12 This switch depicts the various options for lighting on this tractor. Credit: J. Mathison.

Some Rules for Black Controls

Here are a few more rules for using the black color-coded controls. These controls can be knobs, toggle or rocker switches, levers, or pedals.

- Lift controls (figure 2.13) operated from the tractor seat must be clearly identified and are found on the right side of the cab.
- Front-end loader controls must be located on the right side of the operator.
- Foot controls must be pushed forward to lower equipment.

A black control knob means
"position or adjust."

Figure 2.13 High lift controls are color-coded black. Credit: J. Mathison.

Location and Movement of Tractor Controls

Tractors are designed for multitasking (doing many jobs at once). Several functions may occur at the same time. A safe operator will be able to maintain control of each function during operations, for example, when mowing hay with a 12-foot-wide mower-conditioner. When approaching an uphill grade, the operator must downshift (ground motion control). A huge rock in the field also means the operator must raise the mower head to avoid damage to the knife guards and knife sections (machine positioning control). The operator is steering, shifting, and using remote hydraulic controls simultaneously.

Control Devices and Functions

Tractor manufacturers try to help tractor drivers identify controls and use them correctly. For example, specific controls are located on the same side of the operator's seat and move in the same direction to obtain a desired effect. But many older tractors may have controls or directions of movement different from newer tractors.

Three common types of control devices are used on a tractor.

They are:

1. **Foot controls**—Pedals
2. **Hand controls**—Levers, toggles, switches, knobs, and buttons
3. **Combination hand and foot controls**—Engine throttles

These controls apply brakes, operate the clutch, speed the engine, change gears, lock the differential, steer, stop the engine, lift implements, engage the PTO (figure 2.14), and control electrical and hydraulic flow. Computer functions are also part of the control panel on modern tractors.

Figure 2.14 A hand-operated PTO control. Credit: J. Mathison.

Movement and Location of Controls

Using the same location and direction of motion for controls makes it easier to operate the tractor safely and efficiently. Below are the most common rules for the location and direction of motion for tractor controls, including some combinations of control functions. There are several exceptions to these rules. Study the operator's manual for all the tractors *before* operating the tractor. Consult the tractor owner to be sure they explain where a control is located and what happens when it is moved

A control on an older tractor may not perform the expected task.

Brake control—Foot brake pedals must be on the right side. Push the brake forward and/or downward to engage. If a hand brake is provided, it can be on either side and must be pulled to be set. Brake locks may be lifted to be set.

Clutch control—A foot clutch pedal must be on the left side. The pedal is moved forward or downward for disengagement. A hand-operated clutch can be on either side and must be moved toward the operator to be disengaged.

Combination clutch and PTO control—A foot-operated combination will be on the left side and be moved forward and/or downward to cause clutch and PTO disengagement.

Combination clutch and brake—A foot-operated combination will be on the left side and moved forward and/or downward to cause clutch disengagement and brake engagement.

Power takeoff (PTO) control—A hand-operated PTO control can be on either side and will be moved upward or forward for engagement and rearward or downward for disengagement.

Engine speed control—The control is on the right side. If the hand-operated control is next to the tractor seat, the direction of motion must be forward or upward to increase engine speed and rearward or downward to slow engine speed.

If the hand-operated speed control is near the steering wheel, the direction of motion must be rearward and/or downward to increase speed and forward and/or upward to slow engine speed.

If a foot-operated control is provided, it must be on the right side and moved forward and/or downward to increase speed.

Ground speed control—A hand-operated forward-reverse directional (non-variable speed) control must be moved forward for forward travel and rearward for reverse. A hand-operated variable speed control (figure 2.15) must be moved forward and/or upward to increase speed and rearward and/or downward to decrease speed.

Figure 2.15 The ground speed control on the tractor is orange. Orange is the color code for ground motion controls. Credit: J. Mathison.

A hand-operated combination direction and variable speed control must be moved forward or away from the operator—from the neutral position—for forward travel and increasing speed. To reverse and to increase reverse speed, the control is moved rearward or toward the operator, from a neutral position.

A foot-operated combination direction and variable speed control(s) must be on the right side. If a single pedal is used, it must produce forward motion with a forward or downward toe motion, and move in reverse with a rearward or downward heel motion. If two pedals are used, the inner pedal must be moved forward or downward for forward motion, and the outer pedal must be moved forward or downward for backing up. Also, the forward or downward pressure on both pedals must increase speed and automatically return to a neutral position when a foot is taken off the pedal.

Differential lock control—A differential lock must be moved forward or downward for engagement.

Lift controls for implements or attachments—Lift controls (figure 2.16) must be on the right side. A hand-operated control must be moved forward, downward, or away from the operator for lowering, and backward, upward, or toward the operator for lifting.

Figure 2.16 The two black knobs are lift controls for implements or attachments. Credit: J. Mathison.

Tractor Operation Symbols

Operation symbols were designed to promote and improve tractor and equipment use and safety in the agricultural workplace. Operation symbols transmit information with minimal use of words and are displayed in a standard way.

Symbols are designed to quickly help the operator to recognize a function or malfunctions. See the operator's manuals to learn more about these symbols. *Learn what each symbol communicates*. This information helps the operator prepare for work or respond to a malfunction. A complete exhibit of agricultural equipment operator control and display symbols can be found at **standards.globalspec.com/std/889740/asabe-s304**. Here are some of the most common and important symbols (figures 2.17–2.29).

Figure 2.17 This symbol represents diesel fuel. Be sure of which fuel you are putting into the tank. Credit: PSU Ag Safety.

Tractor operation symbols give quick information about functions and malfunctions.

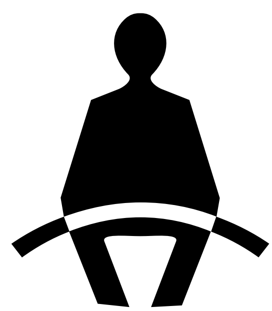


Figure 2.18 This symbol serves as a reminder to use the seat belt. A tractor equipped with a ROPS can save your life when used with the seat belt. Credit: Association of Equipment Manufacturers.

Figure 2.19 This symbol is an ALERT for a malfunction. Alert symbols usually are found in conjunction with another symbol. Credit: J. Mathison.

Figure 2.20 The symbol for oil should draw your attention to checking the oil or the oil fill area. You will see this symbol with engine lubricant and hydraulic systems. Credit: J. Mathison

An oil light or gauge that indicates low oil pressure is a message to stop the engine immediately. Major repairs will be needed if not taken care of right away.

Figure 2.21 Universal symbols provide operating information. The oil can symbol may be used to indicate frequency of oil changes and the SAE number of oil to use. This picture represents an SAW 20 oil changed at 50 hours. Credit: J. Mathison.

Figure 2.22 This symbol shows the only recommended lift point to attach a chain for moving a heavy weight. Damage or injury can occur if any other lift point is used. Credit: J. Mathison.

Oil Change Safety—

For People and the Earth

- Collect used oil in an open-top container, then transfer it to a sealed container clearly labeled "used motor oil." On farms, used oil may be transferred to a 55-gallon oil barrel because the volume of used oil can be large.
- Take the used oil and filter to a designated recycling location.
- Special care must be taken with oily rags and towels. Oil dries through oxidation, rather than evaporation, and oxidation creates heat and possibly fire. Oily rags should be hung outside to dry in a safe area or spread flat in a single layer, making sure they are weighted down outdoors. They should not be in a pile. Once they are dry and stiff, they can be disposed of in the regular trash. For more information: **diy.dunnlumber.com/projects/how-to-safely-dispose-of-oil-soaked-rags**
- For more information about oil changes: **pca.state.mn.us/living-green/changing-your-oil-earth-friendly-guide-do-it-yourselfers**

During tractor operation, these symbols will indicate what to do or what is happening.

Figure 2.23 This symbol shows the engine speed (rotations per minute). Credit: J. Mathison.

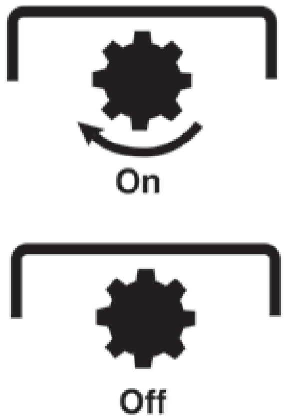


Figure 2.24 The PTO symbol indicates the engaged/disengaged function. Credit: J. Mathison.

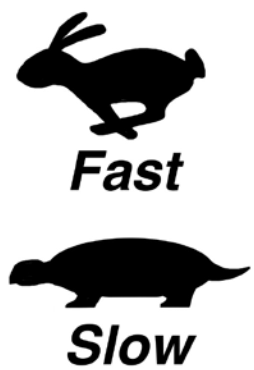


Figure 2.25 The throttle symbol reminds us of the slow turtle and fast rabbit story, or speed control. Credit: J. Mathison.

The engine oil pressure and ammeter symbols are used to draw attention to malfunctions during operations.

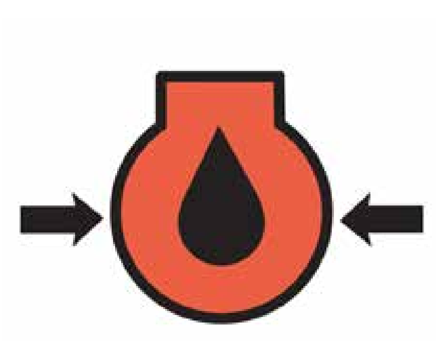


Figure 2.26 The engine oil pressure symbol draws your attention to malfunctions during operation. It glows red when pressure is insufficient. Credit: J. Mathison.

Figure 2.27 The ammeter or generator symbol draws your attention to malfunctions during operation. It glows red with insufficient charge rate. Credit: J. Mathison.

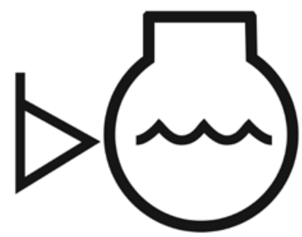


Figure 2.28 This symbol shows engine coolant level. Credit: J. Mathison.

Figure 2.29 This symbol shows whether the clutch is engaged or disengaged. Credit: J. Mathison.

Tractor Accessory Symbols

Operators may need to use the accessories on a tractor. Operation symbols will be found on the equipment as well as on the tractor.

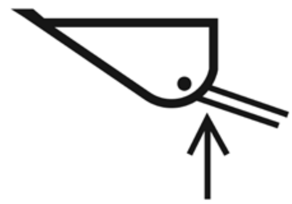


Figure 2.30 This symbol indicates that the resulting operation will raise the high-lift bucket. This is a positioning and adjusting control symbol. Credit: J. Mathison.

Figure 2.31 This symbol indicates that the resulting operation will tilt the high-lift bucket to the rear. Credit: J. Mathison.

Some symbols may be more difficult to understand.

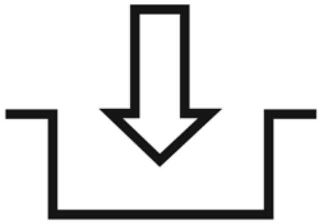


Figure 2.32 This sign shows an engage control function. Recall that engagement controls are yellow on newer tractors. Remote power operation occurs. Credit: J. Mathison.

All the symbols used may not be visible on every tractor, but studying them for future reference is good practice.

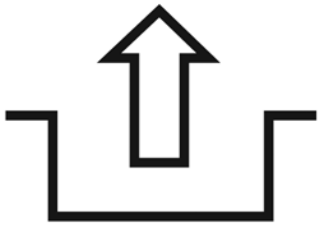


Figure 2.33 This sign shows a disengage control function. Engagement controls are yellow on newer tractors. Credit: J. Mathison.

Figure 2.34 Older tractors will not have operation symbols. What might you find on this tractor to tell you the information you need about oil pressure and engine temperature? Credit: J. Mathison.

Make an effort to learn all the symbols. Keep the operator's manual nearby.

Preventive Maintenance and Pre-Operation Checks

Performing tractor maintenance is a critical task for every operator. This section discusses the proper way to maintain a tractor to avoid costly and unnecessary repairs.

Pre-Operation Checks

A good operator uses a daily written checklist of items and systems to inspect before starting the tractor. This is often called a pre-operation checklist.

Things to check include:

- fuel level
- coolant level
- engine oil level
- hydraulic oil level
- battery condition
- lug nuts and wheels
- tire condition
- loose or defective parts
- slow-moving vehicle emblem
- fluid leaks
- operator's platform/steps
- seat adjustment
- seat belt
- fire extinguisher
- lighting/flashers
- visibility from operator's seat

Look out for these issues when performing a pre-operation check:

- low tires and leakage from the valve stem
- oil or hydraulic leaks on the ground beneath the tractor
- a frayed or worn fan belt
- corroded battery terminals
- loose bolts or lug nuts on wheels
- dirty cab windows that obstruct vision
- headlights or warning lights with broken bulbs or glass

- a slow-moving vehicle emblem faded or distorted in color or shape
- a fire extinguisher with a pressure gauge in the "recharge" range
- tools or supplies on the operator platform

Start the engine only after completing a walk-around inspection, making certain all systems are ready.

Safe Starts

Some utility and lawn tractors may have safety start systems. If so, the owner should also have one (or both) of these in good working order:

Seat switch/safety interlock—Prevents starting the tractor if the operator is not in the seat.

Neutral-start safety switch—Prevents the tractor from starting if the tractor is in gear.

Fuel, Oil, and Coolant Levels

A tractor makes farm work more efficient. It is also a huge investment. Even a midsize tractor may cost $40,000 or more.

The tractor must be kept in top operating condition. Downtime for engine and tractor repairs is costly in parts and labor as well as potential delays other farm chores. A crop in the field may be lost because of harvest delays. Crop losses can lead to increased costs to purchase replacement feeds or protein supplements for livestock. Therefore, tractor and equipment pre-operation checks are an economic necessity. A damaged engine or an empty fuel tank (figure 2.35) at the farthest field from the barn is not acceptable for the skilled operator.

This section discusses the importance of checking the fluid levels before touching the tractor ignition switch. Always check:

- fuel
- coolant
- oils

This habit assures the tractor engine is ready for field work.

Figure 2.35 Before driving the tractor to the field, check for the possibility of an empty fuel tank. If you run out of fuel during a workday, it causes avoidable downtime. Credit: J. Mathison.

Save an engine from costly repairs: check the fuel, coolant, and oil levels before starting the engine.

Why Operators Should Check Fuel, Oil, and Coolant Levels

Fuel

Check the fuel level before leaving the barnyard or shop area. Do not assume someone else has done this job. Failure to check the fuel level may result in lost field time. It could also result in the need to mechanically bleed air from diesel fuel lines in some older tractors.

Be sure of the correct fuel needed. Do not fill diesel fuel tanks with gasoline, and vice versa.

Oil

Oil bathes metal surfaces to prevent the heat of friction from damaging the moving parts. Low engine oil allows engine parts to overheat, expand, and "seize" the engine. Overfilling the engine oil results in oil seal damage.

Check oil levels daily using the dipstick to prevent engine damage.

Coolant

Coolant fluid (water and antifreeze) takes heat away from the engine. Air flowing across the radiator then reduces the coolant temperature. Lack of coolant causes the engine to overheat (figure 2.36). Water used as a coolant by itself will cause rust in the water pump.

Check coolant levels while the engine is cold to prevent severe scalds.

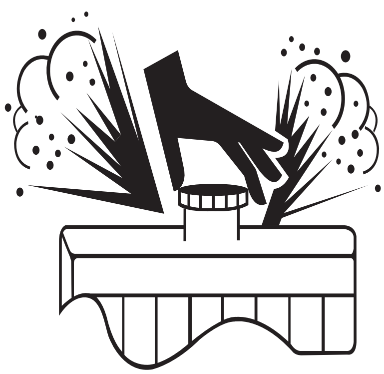


Figure 2.36 Never remove a radiator cap from a hot engine. Steam and hot water from the radiator can scald your skin. Credit: Association of Equipment Manufacturers.

If the engine light comes on while operating the tractor, shut down immediately.

Lead Acid Batteries

Lead acid batteries provide a source of electrical current to start an engine and power tractor accessories, such as lights, emergency flashers, instrument panel gauges and meters, computerized digital read-outs, and other functions. Tractor electrical power may be used to operate and monitor functions of towed equipment.

Battery electrical current results from a chemical reaction produced by sulfuric acid and water mixture. This chemical solution, called electrolyte, can burn skin and eyes. The energy produced is stored as positive (+) and negative (-) electrical charges on the battery plates. An explosive gas is produced by this reaction as the battery charges and discharges.

Modern tractors may have one or two batteries to provide current to the starting motor (starter).

Correct battery care and use will provide countless starts of the tractor engine in a safe manner.

Table 2.2. Battery hazards.

Part	Function
Battery case	A container to hold the battery acid solution and electrical storage plates
Battery plate	Holds electrical charges (+) and (-)
Terminals	Connect to the storage plates and become the connecting points for battery cables leading to the starter (+) and the ground (-)

Use safety goggles and protective clothing when working with a lead acid battery.

Table 2.3. Battery hazards.		
Hazard	**Definition**	**Safety precautions**
Explosion	Battery acid produces hydrogen gas, which is explosive. A spark can lead to fire (of dust, chaff, etc., around the battery) or explosion of hydrogen gas from the battery itself.	Check fluid level often to prevent gas buildup. Maintaining proper fluid levels reduces the space in a battery where gases can accumulate.
Chemical burn	The electrolyte solution in a battery is caustic to the skin and eyes and can burn holes through clothing.	**Use splash-proof safety goggles and rubber gloves**. Keep the battery posts clean of corrosion.
Electrical shock	The electrical charge of a battery may be only 12–26 volts, but with the effects of the ignition coil on spark ignition, engines may produce voltages in the range of 100,000 volts. This can cause a severe shock. Wiring and electrical parts can be damaged.	Keep tools and parts away from the positive (+) terminal. It is best to remove the ground cable first when removing a battery or working on any part of the electrical system. When replacing the battery, connect the ground cable last.

Battery Safety Procedures

- Check battery fluid levels often. Low electrolyte levels increase the space where hydrogen gas can accumulate.
- Prevent electrical sparks by keeping tools and parts away from the positive (+) terminal. The battery cable leading to the starter is usually the positive, or "hot" wire. Cap it with an insulating material when working near it.
- When removing a battery for replacement or bench work, remove the ground cable first.
- When replacing a battery, install the ground cable last.
- Use safety goggles, long sleeves, and rubber gloves when refilling battery liquid. Distilled water is recommended for the refill. Any clean water can be used in an emergency if the battery is nearly dry.
- Keep battery terminals clean of corrosion for best electrical contact. Prevent the corroded material from getting on skin or in eyes.
- Any battery acid spilled on skin, should be flushed off with water immediately.
- Battery acid splashed in eyes, should be flushed with warm water for at least 15 minutes. Seek medical attention.

Using Jumper Cables

If batteries are not cared for properly (see Battery Safety Procedures above) or if they are nearing the end of their useful life expectancy, (e.g., a 60-month guaranteed battery, which has 54 months of use), the battery may fail to start the tractor. Many times, battery failure will come at the onset of cold weather.

Batteries can also lose a charge when not used for extended time periods. It may be necessary to use a booster battery and jumper (booster) cables (figure 2.37) to start the tractor, truck, or car.

This section discusses the correct procedures to boost or jump-start a 6- or 12-volt battery to start an engine. For other voltage ratings, consult the tractor or battery operator manual or manufacturer recommendations.

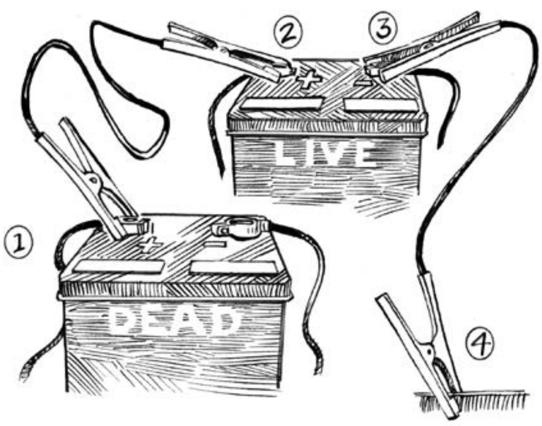


Figure 2.37 Battery polarity: A battery has two poles or posts. The positive battery post is usually marked POS, P, or (+ or red) and is larger than the negative post, which is usually marked NEG, N, or (– or black). Connect positive to positive and negative to negative terminals to jumpstart the battery. The cable for the positive connection is typically red or yellow, and the cable for the negative connection is typically black. Connect the battery posts in the number sequence shown. Connection 4 attaches to the engine block of the stalled vehicle. Unless absolutely necessary, avoid jumpstarting vehicles. Credit: J. Mathison.

Battery Jumping

Tools needed

- safety glasses
- approved booster cables of 4-, 6-, or 8- gauge wire. Lighter wire (higher wire gauge number) will not carry enough current to jump-start the battery.
- wrenches to remove battery cables
- battery terminal cleaner
- booster battery usually from another tractor or vehicle.
- rubber gloves

Jump-starting a tractor: The red cable goes to the POSITIVE (+) battery terminal, and the black cable goes to the NEGATIVE (-) battery terminal on the good (charged) battery.

Steps to Jumping a Battery

Jump-starting an engine with a drained battery is the same whether the drained battery is in a tractor, truck, or car. Normally, another tractor, truck, or car battery is used to try and start the vehicle with the drained battery.

Important: Most vehicles have negative ground batteries. Be sure both the drained battery and the booster battery have negative grounds.

Follow these steps for jump-starting a tractor with a drained battery:

1. Pull the tractors next to each so they are not touching, and turn off both ignitions.
2. Connect the positive (+, yellow, or red) clamp of the jumper cable to the drained battery's positive terminal.
3. Connect the other positive (+, yellow, or red) clamp of the cable to the positive terminal of the booster battery.
4. Connect the negative (– or black) clamp of the cable to the negative terminal of the booster battery.
5. Connect the other negative (– or black) clamp of the cable to the vehicle's engine block or other metal surface of the tractor to be started away from the drained battery. This serves as the ground or connection point.

Caution: Do not connect clamp to carburetor, fuel lines, or sheet metal body parts. Connect to a heavy-gauge metal part of the frame or engine block.

6. Make certain all cables are clear of fan blades, belts, and other moving parts of both engines and everyone is standing away from the vehicles.

7. Start the tractor with the booster battery.
8. Allow 1–5 minutes for the drained battery to accept a charge.
9. Try to start the tractor with the drained battery.

IF VEHICLE STARTS:

Allow the engine to return to idle speed. Remove the cables in the reverse order they were put on.

1. Remove the negative (– or black) clamp from the frame of the vehicle with the drained battery.
2. Remove the negative (– or black) clamp from the booster battery.
3. Remove the positive (+, yellow, or red) clamp from the booster battery.
4. Remove the positive (+, yellow, or red) clamp from the formerly drained battery.

IF ENGINE DOES NOT START:

Wait a few minutes and try again. If it still doesn't start, check for other problems.

Be sure to connect the jumper cables using the correct procedure to avoid sparks and damage to the battery or personal injury.

Tire and Wheel Condition

Tractors are traction machines! Better traction comes from good tires. Tractor tires can cost several hundred dollars each. Estimates show tractor tire repair and replacement comprise nearly 30% of the total repair costs during a tractor's lifetime. Operators are responsible for protecting this valuable traction component.

Tire Basics

These simple activities can extend the life of tractor tires:

- Check tire pressure regularly.
- Use wheel weights to reduce excess slippage, which can damage the tire.
- Drive carefully to avoid damaging tires and wheels.
- Make tire repairs promptly.

Tire and Wheel Hazards

Tractors are not built for high speed. *High speeds* on paved roads reduce tire life (figures 2.38–2.41). Unpaved roads can increase the chance for large stones to damage the tires.

Foreign objects can puncture tires. All farms have their share of sharp rocks, hidden field objects, and construction debris. Fields near rural roads may have glass bottles and metal cans. Be alert for those hazards and other objects that can damage tires.

Improper use can ruin tires. Turning too tightly and gouging the tire into towed equipment leads to cut tires. Most tractors have no shock absorbers, so the tire must absorb all ground shocks. Avoid hitting objects that can break tire sidewalls.

Figure 2.38 Tractor tire components include the tire, the rim or wheel, an inner tube with valve, and often a calcium solution filling about 80% of the inner tube. The calcium fill line is 80% if calcium or similar solution is used. Credit: J. Mathison.

Some rear tractor tires are filled with a calcium solution to add weight to the tractor for improved traction.

Tire and Wheel Defects

Figure 2.39 Worn tire treads and dry rot make for poor traction and risk downtime due to a blowout. Credit: J. Mathison.

Figure 2.40 Damaged rims from careless use may cause damaged tire beads and flat tires. Credit: J. Mathison.

Figure 2.41 A leaking valve stem released calcium solution, which rusted the rim. A major expense would be incurred to replace the tire. There is also a severe safety hazard in using this tractor. Credit: J. Mathison.

Tractor tires may cost hundreds of dollars to repair or replace.

The Operator Platform

Compare the tractor operator platform (figure 2.42) to the cockpit of a fighter jet. Both the tractor and jet fighter have:

- steps to climb on board
- adjustable operator seat with seat belt
- multiple controls at hand and foot positions
- high visibility from the operator's seat

Keep these similar work areas free of obstructions for safe operation.

Could the pilot of the fighter jet be able to fly in a moment's notice if:

- the steps were covered with mud and manure?
- the cockpit were filled with chains, grease guns, tools, and hitch pins?
- the windows were covered with pesticide spray drift or other materials?
- the pilot could not reach the controls because of a poorly adjusted seat?

Figure 2.42 The operator's platform of a tractor is not a tool box. You must have room to operate hand and foot controls. PTO levers, differential locks, foot throttles, and brake locks have to be engaged from the floor position. Soda cans and tobacco snuff containers can roll under control pedals and prevent correct timely operation. Credit: J. Mathison.

The tractor platform serves as the cockpit of this farm tool. Keep the steps clear and clean. Use the seat belt. Keep windows and mirrors clean.

Steering and Seat Adjustment

Each person who operates the tractor will be a different height and weight. Check and adjust the seat and steering (figure 2.43) to comfortably reach all controls.

Seat controls may be levers or knobs and will be black in color. They may:

1. Release the seat to tilt it away from rain if the tractor is sitting outside.
2. Position the seat higher, lower, closer, farther, or to a different tilt position from the steering wheel and foot pedals.
3. Adjust the seat for the weight of the operator.
4. Be sure the seat belt is also adjusted for the seat.

Figure 2.43 The steering wheel should be adjusted as soon as you are seated. In the correct position, your arms are bent at a 90-degree angle as you hold the steering wheel. Credit: J. Mathison.

Seat belts keep tractor drivers from being thrown out of the cab or off the seat during rollovers. Wear the seat belt!

Starting and Stopping Diesel and Gasoline Engines

Starting an engine is more than turning the ignition key. The safe operator is prepared to think clearly and to react to all the conditions surrounding the tractor. Tractors may vary in design and layout of the instrument panel and ignition system (figure 2.44), but starting and stopping gasoline and diesel engines involves only slightly different procedures.

Figure 2.44 Whether it is an older tractor or right out of the showroom, it may not be easy to see how to start the tractor without a demonstration or reading the operator's manual. If you are not sure, have someone show you first. Credit: J. Mathison.

Before Starting the Engine

Review *gasoline* engine operation:

- starter motor spins the engine
- fuel and air mix enters combustion chamber; spark plug ignites mix
- engine starts

OR

Review *diesel* engine operation:

- starter motor spins the engine and activates the fuel pump
- fuel droplets are sprayed into super-hot combustion chamber
- engine starts

For both engines use a pre-operation check:

- check oil, fuel, and coolant levels (cold engine only)
- check the tires
- check the controls for neutral positions

For all engines, avoid bypass starting (see Bypass Starting Dangers below). Some operators may try to bypass the safe start system on a tractor. This is an unsafe practice. If the tractor is in gear during a bypass start, the tractor will move forward and crush the operator. Start the tractor ONLY from the seat.

Do not start any engine inside a closed building—the carbon monoxide gases can become deadly.

Starting a Gasoline Engine

Follow these steps after fastening the seat belt.

1. Push the clutch in, and make certain the tractor is in a neutral gear.
2. Adjust throttle to ⅓ open.
3. Choke the engine on cool days.
4. Turn starter key to "on" (figure 2.45).
5. Check indicator lights/gauges for oil pressure, temperature, and electrical charge.
6. Turn the key to "start" position, but do not crank the engine for more than 10–30 seconds to avoid damage to the starter or running down the battery.
7. Recheck gauges, especially the oil gauge.
8. Warm up the engine at 800–1,000 rpm for a few minutes.

Figure 2.45 Turn the ignition key to the start position. Do not hold the key there for extended periods of time. This can burn up the starter motor or drain the battery of its charge. Credit: J. Mathison.

Stopping a Gasoline Engine

1. Throttle back to idle speed.
2. Place tractor in PARK or neutral and set brakes.
3. Turn off ignition key, and remove the key to prevent accidental start-up by an untrained person.
4. If parking on a hill, place the transmission in a low gear with brakes set.

A cold engine must be choked to start easily. Choking increases the fuel to air ratio during cold weather.

Starting a Diesel Engine

Follow these steps after the seat belt is fastened.

1. Push the clutch in, and make certain the tractor is in a start or neutral gear.
2. Adjust throttle to ⅓ of the working range.
3. On cold days, turn ignition key to warm the glow plug, which preheats the combustion chamber air. ***Do not use an ether starter fluid.***

4. Check indicator lights/gauges for oil pressure, temperature, and electrical charge.
5. Turn the key to “start” position, but do not crank the engine for more than 10 to30 seconds to avoid damaging the starter or running down the battery.
6. Recheck gauges, especially the oil gauge.
7. Warm up the engine at 800–1,000 rpm for a few minutes.

Stopping a Diesel Engine

1. Throttle back to idle speed.
2. Place tractor in PARK or neutral and set brakes.
3. Turn off ignition key, and remove it to prevent accidental starting by an untrained person.
4. Pull the red fuel pump shut-off control rod.
5. If parking on a hill, place the transmission in a low gear with brakes set.

Turning the key to the “off” position usually does not stop a diesel engine. You must also shut off the fuel pump.

Mounting and Starting the Tractor

Safe Tractor Mounting

- Keep the operator platform free of tools, equipment, mud, and other debris.
- Use handholds and steps when mounting the tractor (figure 2.46). Try to keep three points (two hands and one foot or two feet and one hand) on the tractor at all times.
- Adjust the seat and steering wheel (if necessary).
- Adjust and buckle the seat belt (if the tractor has a ROPS).
- Check the major controls (PTO, hydraulics, gearshift stick) for the neutral (or PARK) position.

Use three-point mounting: either two hands and one foot; or two feet and one hand to climb into the driver’s seat.

Figure 2.46 Mount a tractor safely by using the handholds and steps. Credit: J. Mathison.

Before Starting the Engine

- Perform pre-operation checks to verify the area immediately around the tractor is clear of people, animals, tools, and equipment.
- If the tractor is inside a building, open the building as much as possible to avoid a carbon monoxide fume buildup.
- Review the tractor’s instrument panel.

Bypass-Starting Dangers

Safety start systems have been in tractors for many years. The most common example of the safety start system requires the gearshift to be in neutral and the clutch to be depressed for the tractor to start. Some newer tractors may also have a switch in the seat to prevent the tractor from starting if the operator is not sitting in the seat. Safety start systems encourage operators to start their tractors while in the tractor seat—the safe place to be.

There are ways to bypass safe start systems. Unfortunately, an operator who makes this mistake in judgment may also misjudge the location of the gearshift. If the tractor is in gear while attempting to bypass-start the tractor, it may lurch forward. The rear wheel can run over and crush the operator. Every year experienced and inexperienced tractor operators die from bypass-starting. Do not be one of them!

Start the tractor engine from the seat only.

Stopping and Dismounting the Tractor

Shutting Down the Tractor

At the end of a day, there are many things to consider when preparing to park and turn off the tractor.

- Engine cool down—Manufacturers suggest cooling the engine for several minutes at a fast idle (800–1,200 rpm) to prevent internal damage to hot engine parts. While letting the engine idle to cool, check all systems on the tractor. Then stop the engine.
- Hydraulic system—Even if the hydraulic system was recently used, static pressure keeps hydraulic lines pressurized. Work the hydraulic controls to relieve the pressure. It will be easier to attach the hydraulic lines later.
- Stop and park on the most level ground possible. Set the brakes (both brakes should be locked together) and place the gearshift in PARK.
- Lower all attached equipment to the ground.
- Place all controls and switches in an off, neutral, or locked position.
- Chock wheels if a heavy load is attached to the tractor to prevent runaways (use a minimum of two chocks).

Turning the tractor off involves more than turning the ignition key to the “off” position.

Safe Tractor Dismounting

The keys to safely dismounting are:

- Keep the operator platform free of tools, equipment, mud, and other debris.
- Face the tractor, and use handholds and steps provided. Try to keep three points (two hands and one foot or two feet and one hand) on the tractor at all times. Many operators have twisted an ankle or broken a bone by recklessly jumping off tractors.
- Take the key. Untrained operators, children, and visitors cannot start the engine if the keys are removed.

Remove the ignition key to prevent untrained people from starting the tractor.

Moving and Steering the Tractor

A safe and effective tractor operator can move the tractor in the proper direction and maneuver around field obstacles without damage. A well-trained operator can:

- Start the tractor moving without stalling, jerking, or lunging.
- Steer the tractor with attached implements in and around buildings, fences, and crops without damage to the tractor, equipment, or property.

Important: Tractors are traction machines. They are not made for speed or for fun. “Popping the clutch” or doing “wheelies” to show off can result in damage, injury, or death. The tractor must move without rearing up at the front end.

Important: Tractors and implements are wider and longer than cars. Tractor operators learn to judge how much space is needed to turn or to drive between objects.

Before the Tractor Moves

What makes the tractor move forward or backward?

The power train provides a means of transmitting power from the engine to the point of use (the drive wheels). The mechanism that functions as a switch to disconnect the rotating crankshaft of the engine from the transmission gears may be a clutch, a hydraulic device, or an electro-hydraulic mechanism. These serve three purposes:

- allow for a smooth start
- interrupt power while changing gears
- interrupt power when stopping

There may be a foot control pedal, hand control lever(s), or joystick(s) to control tractor movement. Remember these are orange color-coded controls. Ask for help to get the details of a task.

Transmission and Clutch Types

Transmissions can be divided into three general categories:

- Manual shift transmissions (figure 2.47), in which the operator uses one or more shift levers to change gears and power range.
- Hydrostatic transmissions, in which the operator pushes a control lever or pedal to engage a hydraulic pump to a hydraulic motor to turns the drive wheels.
- A combination of gear-driven and hydraulically assisted transmissions in which the transmission speeds can be altered by lever or button control and the direction of travel changed by way of a shuttle shift lever (reverser). These units may have a clutch pedal for stopping movement.

Tractor manufacturers may use a combination of clutches and transmission controls. Check the operator’s manual or ask a supervisor how to operate the specific model of tractor.

Figure 2.47 Remember that orange-colored control levers indicate ground motion controls. Study the gear shift pattern on the tractor you are operating. Use a lower gear to start the tractor moving. Use a higher gear for operation. Higher gear use with heavy loads may stall the engine or cause rearward overturns. If the shift pattern is difficult to locate, ask someone who is familiar with the tractor to show you the shift pattern. Credit: J. Mathison.

Skills for Moving the Tractor

Before attempting to move a tractor, examine the operator’s manual and have a qualified operator demonstrate what to do.

To start moving the tractor:

1. Check the controls as in Ground Motion Controls above, adjust the seat, and fasten the seat belt.
2. Start the engine with the brake and clutch fully depressed. Many tractors require a PARK or a neutral-start position for the engine to start.
3. Select a low starting gear to begin moving the tractor with or without a load.

4. After checking the area around the tractor, increase engine speed slightly; slowly engage the transmission until the tractor begins to move.
5. Release the clutch and brakes fully once moving. Partial engagement (riding the clutch) can heat and wear the clutch parts.
6. Increase speed and change gears as the task requires.
7. To stop movement, activate the clutch control pedal or lever and apply the brakes.
8. When stopped, place the shift lever in the PARK position. Lock the brakes.

Use speeds appropriate to the task. Excessive ground speed can negatively affect the operation of towed equipment.

Steering Involves Many Concepts

Steering involves several concepts, each dealing with spacing. Know the:

- width and length of the tractor
- width and length of the tractor and an attached implement
- space needed to turn the tractor and equipment around a building or object
- differences in the turning radius of narrow front-end versus wide front-end tractor steering
- how to steer or control slippage on steeper slopes using individual wheel brakes on the tractor

Because the tractor's brakes may be used to brake each wheel separately, they can be used to make slight steering adjustments. Do not overdo this practice, because brakes can wear out quickly.

Caution: Lock brakes together for roadway travel. Pushing one brake at high speeds can cause the tractor to be thrown sideways, resulting in a side overturn.

Use both hands to steer the tractor. A hole in the field can jerk the wheel from the operator's hands.

Turning Corners, or Cornering

Before attempting to corner in a tractor (figure 2.48), have a qualified operator demonstrate what to do. Each tractor and implement will occupy a different space and corner differently. Know the relationship between the tractor and any towed implement. A too-tight turn can cause the implement to pinch and possibly tear the tractor tire.

To turn a corner with the tractor and towed implement:

- Move as far away from a building and object as the roadway will permit.
- Drive in a long arc around the corner to prevent jack-knifing the tractor and machine.
- Observe the inside turning radius of the tractor and implement. A turn that is too tight can cause damage to the tractor, the tires, or the towed equipment.
- As the turn is completed, observe the outside or opposite side of the tractor to be sure it has clearance from any other objects.

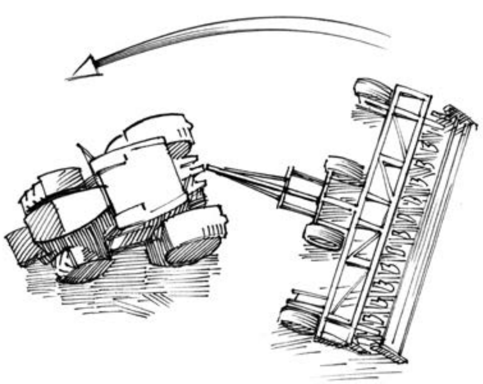


Figure 2.48 Too tight of a turning radius can damage tractor, tires, or implement. The radius shown here is for a wide turn. Credit: J. Mathison.

Operating a Manual Shift Transmission

Many people call a manual shift transmission a "stick shift." A gear shift lever on the tractor operator's platform allows the operator a choice of gears and speeds. The tractor operator must manually shift the gears to change the speed of the tractor. Properly shifted gears result in a smooth transition. Improper shifting causes clashing gears and increased transmission wear.

How It Works

Pushing in on the clutch pedal disengages the friction disk (clutch plate) that turns between the transmission and the engine. This allows the engine to continue to run, but the gears will stop turning.

As the gears slow down, the gear shift lever can be used to slide other gears into place to change direction (reverse) or change ground speeds. There may be only a few choices, such as reverse, 1st gear, 2nd gear, and 3rd gear, or twice as many gear choices if the tractor is equipped with a high and low range transmission, which uses a second shift lever.

Gear Shift Pattern

From the operator's seat, drivers should find the gear shift lever. Notice it operates within a notched device that holds the gear shift in position until the gears are changed. The notched part may have a lettered decal or numbers embossed into the steel case or in the shift lever knob. Sometimes these are worn so much they are no longer visible. The gear shift pattern may resemble the letter H (figure 2.49a), but there are other possibilities as well (figure 2.49b, c).

If the pattern is worn away, check with a supervisor or find the operator's manual. If no one is available to demonstrate the gear shift pattern, follow these steps:

1. Make sure the area all around the tractor is clear of people, animals, and machinery.
2. Hold the brake tight.
3. Place the tractor in a gear while releasing the clutch slowly to see what direction or speed begins to occur. Try each gear.

If the gear shift pattern isn't visible, ask a supervisor for a demonstration.

Figure 2.49a The typical "H" pattern gear shift choice. Credit: J. Mathison.

Figure 2.49b There may be 5th or 6th gear choices as well. Credit: J. Mathison.

Figure 2.49c A high-low range shift lever found near the stick shift provides a faster or slower speed for a particular gear. These symbols may be missing or worn, causing the operator to have to ask for assistance or to locate the gear pattern themselves. Credit: J. Mathison.

Which Gear Is Used?

The tractor is a traction machine. This means the tractor is used to pull a load. Driving fast is not the proper choice for a heavy load.

Tractors work more efficiently in a higher gear with a reduced throttle setting. When pulling a light load use a higher gear and reduce the throttle to maintain the desired ground speed. This is difficult to do when using the PTO because most PTO-driven machines must be operated at a rated speed to perform properly. Engine speed/ PTO speed is often displayed on the tractor instrument panel. Ask for help or check the operator's manual to understand the gear to select in this situation.

Moving the Tractor

With the clutch and brake pedals pushed down to disengage the transmission and engage the brakes, and with the tractor engine running, increase engine speed slightly and slowly let up on the clutch pedal until movement is apparent. Then, slowly let off the brake pedal at the same time. When moving, take feet off the pedals because partial pressure on the clutch pedal (riding the clutch) will cause wear on the clutch plate and bearings in the transmission case.

To change gears, reduce engine speed, press in on the clutch pedal, move the gear shift lever to the next higher or lower gear and slowly release the clutch pedal. Gear up or down as needed. Be prepared to use the brakes when necessary.

Incorrectly timing engine speed with gear shifting movements can cause the gears to clash.

Other Tractor Transmissions

"Jump on that tractor and move it to the next farm down the road," said the supervisor. For anyone who has driven a tractor, this should be a simple task. Maybe not! Tractor transmissions have come a long way since the manual stick shift. There are many transmission types and combinations on the market and newer ones are introduced regularly. Operators should be trained on each tractor and different transmission they are expected to operate.

Advice for Beginners

With many variations in transmission shift patterns, ask a supervisor to demonstrate how the tractor is effectively shifted for various tasks. This is necessary to prevent personal injury as well as injury to others, and to prevent damage to the tractor or other property.

Use the operator's manual for the specific tractor to learn more about the transmission use.

Use a search tool such as Google to help understand a specific type of transmission.

Transmissions Other than Standard or Stick Shift

Changing gears with a stick shift is inefficient. Tractor manufacturers developed a means of "shifting on the go" (figure 2.50) to improve tractor efficiency and increase operator comfort. The clutch pedal may still be used to disengage the clutch between the transmission and the engine, but chances are newer model tractors will not use a pedal for shifting gears (figure 2.51). Once on the move the simple movement of the power (gear) shift lever gives a greater range of power and speed.

Several variations are shown here (figures 2.52 and 2.53). Operators should become familiar with the transmission they will be using. They should study the operator's manual and ask for assistance from a knowledgeable person.

Figure 2.50 A synchronized shift transmission permits the operator to shift on the go within a range of "synchronized" gears. Credit: J. Mathison.

Figure 2.51 Look on the left side of the steering column. The shuttle shift lever, sometimes called the reverser, allows for ease of changing direction without using the clutch. This lever may serve as the positive park to be used with the parking brake. Some may have to be in a neutral position for the tractor to start. This may be the only time that the clutch pedal is used. Credit: J. Mathison.

Always look for the orange-colored controls.
Some may be faded, or the color may be nearly invisible.

Figure 2.52 Visual monitoring of speed and power range assists the operator in efficient operation. Consult the operator's manual or ask your supervisor for directions so you can properly operate the tractor. Credit: J. Mathison.

Figure 2.53 A contemporary tractor has sophisticated controls and monitoring systems. Use the operator's manual and ask your supervisor to explain the tractor's operation. Credit: J. Mathison.

Asking for a demonstration of how the transmission of a tractor works is smart. Tractors are a large investment and can be damaged if not used properly.

Operating the Tractor in Reverse

Good tractor operation means steering the tractor in the proper direction of operation without damage to it or other machinery. Not all operations are in a forward direction. The tractor and equipment must also be operated in reverse to hitch equipment and move it backward, unload crops, and store machinery.

During reverse travel and steering, the wheels will usually be out of the driver's line of sight. Be aware that the steered wheels point the rear of the tractor in the desired direction.

To back up safely, check the line of travel, accelerate slowly, and have someone help direct if needed. Master this task without any equipment hooked to the tractor before beginning to back up a two-wheel or four-wheel machine or implement.

Reverse Direction Hazards

People, animals, or other objects may be in the line of travel. Skid loaders and industrial equipment have reverse gear alarms to warn others, but tractors usually do not.

Workers who help hitch the implement to the tractor can be crushed if the driver's foot slips from the clutch pedal, the operator drives too fast in reverse, or if the operator steers in the wrong direction in reverse. Do not permit the helper to go between the tractor and implement to be hitched unless the tractor is stopped and the engine is off.

There is a tendency to shift slightly from the operator's seat when looking to the rear. The operator must stay in good contact with foot and hand controls to be safe. If you are the driver, which way should you turn the steering wheel to make the tractor turn to the left when using the reverse gear? Imagine which way the rear of the tractor will go as you turn the steering wheel when moving in reverse.

How To Back Up

1. Be sure seat and controls are adjusted properly.
2. Be sure all people, animals, and objects are clear of the tractor.
3. Engage the clutch slowly, use a low engine speed, and maintain foot contact with the clutch and brake.
4. Turn the top of the steering wheel in the same direction the rear of the tractor should move. For example, to move the rear of the tractor to the left, turn the steering wheel to the left. Likewise, to move the rear of tractor to the right, turn the steering wheel to the right.
5. To back up with a two-wheeled implement attached to the tractor, use the rear of the tractor to force the implement to the desired location. To move the implement to the left, steer the tractor to the right. To move the implement to the right, steer the tractor to the left. This must be done slowly.

Remember, when backing up an implement, turn the steering wheel in the opposite direction you want the implement to move.

Tractor Stability

No other machine is more associated with the hazards of farming than the tractor. Nearly 50% of tractor fatalities come from tractor overturns. Tractors are used for many different tasks. Because the tractor is a versatile machine, operators sometimes stretch the use of the tractor beyond what the machine can safely do. For example, an operator may turn a corner too quickly for the tractor to stay upright. The use of a rollover protective structure (ROPS) and a seat belt can save an operator's life if a tractor overturns while driving.

This section explains the four major reasons and forces that overturn tractors, gives rules for how to prevent tractors from overturning, and discusses the use of a tractor ROPS with a seat belt.

How Tractors Overturn

Center of gravity (CG). The point where all parts of a physical object balance one another.

A pencil balanced perfectly on someone's finger, demonstrates the pencil's CG. This is the part of the pencil resting on the finger. On a two-wheel drive tractor, CG is about 10 inches above and 12 inches in front of the rear axle. Figure 2.54 shows the normal position of a tractor's CG.

Figure 2.54 Expected position of a tractor's center of gravity. Credit: J. Mathison.

Figure 2.55 shows the CG is inside a tractor's stability baseline. Drawing a line to connect all the wheels of the tractor as the wheels set on level ground forms a tractor stability baseline. The line connecting the rear tire ground contact points is the rear stability baseline. The lines connecting the rear and front tire on the same side are the right and left side stability baselines. Front stability baselines exist but have limited use in tractor overturn discussions.

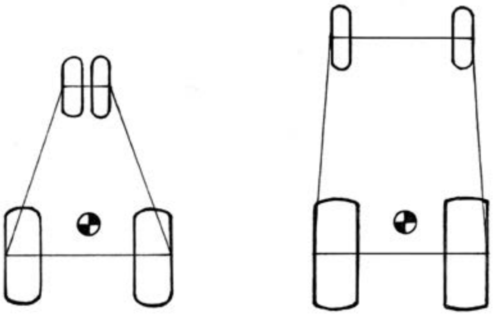


Figure 2.55 The tractor's center of gravity is inside the stability baseline. Credit: J. Mathison.

There are two very important points to remember about tractor CG and stability baselines:

- The tractor will not overturn if the CG stays inside the stability baseline.
- The CG moves around inside the baseline area as the tractor is operated.

As seen in figure 2.55, a wide front-end tractor provides more space for the CG to move around without going outside the stability baseline.

Why the Center of Gravity Moves Around

There are five main reasons why a tractor's CG moves outside the stability baseline:

1. The tractor is operated on a steep slope.
2. The tractor's CG is raised from its natural location 10 inches above the rear axle.
3. The tractor is going too fast for the sharpness of the turn.
4. Power is applied to the tractor's rear wheels too quickly.
5. The tractor is trying to pull a load not hitched to the drawbar.

How the Center of Gravity and Centrifugal Force Result in an Overturn

When a tractor is on a slope, the distance between the tractor's CG and stability baseline is reduced. Figure 2.56 shows how this occurs. On steep slopes, the tractor is already close to an overturn. A small bump on the high side, or a groundhog hole on the low side, may cause the tractor to overturn.

A front-end loader or other attachment mounted on a tractor can raise the tractor's

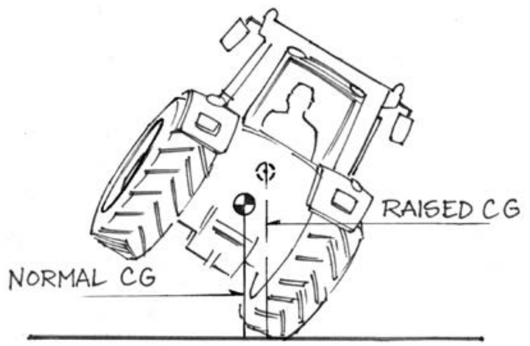


Figure 2.56 When a tractor is on a slope, the distance between the tractor's CG and stability baseline is reduced. Credit: J. Mathison.

CG. When the bucket is raised high, the balance point for the whole tractor is also raised. Figure 2.57 shows how a raised CG makes it easier for a tractor to turn over sideways.

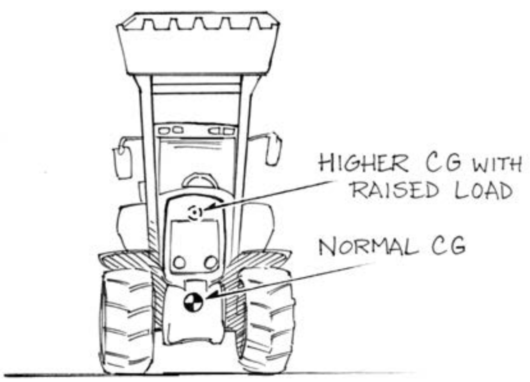


Figure 2.57 A raised CG makes it easier for a tractor to turn over sideways. Credit: J. Mathison.

Centrifugal force (CF). The outward force exerted on objects moving in a circular fashion.

During tractor overturns, centrifugal force is trying to roll the tractor over whenever the tractor is turning. CF increases both as the turning angle of the tractor becomes sharper (decreases), and as the speed of the tractor increases during a turn. For every degree the tractor is turned more tightly, there is an equal amount of increased CF.

Centrifugal force varies in proportion to the square of the tractor's speed. For example, doubling tractor speed from 3 mph to 6 mph increases the strength of CF four times (22 = 2 x 2 = 4). Tripling tractor speed from 3 mph to 9 mph increases CF nine times (32 = 3 x 3 = 9).

Centrifugal force is what usually pushes a tractor over when the tractor is driven too fast during a turn or during road travel. During road travel, rough roads may result in the tractor's front tires bouncing and landing in a turned position. If the tractor starts to veer off the road, overcorrection of steering can result in a side overturn. Centrifugal force is often a factor in tractor side overturns. When the distance between the tractor's CG and side stability baseline is already reduced from being on a hillside, only a little more CF may push the tractor over.

Engaging the clutch of a tractor results in a twisting force, called torque, to the rear axle. Under normal circumstances, the rear axle (and tires) should rotate, and the tractor will move ahead. If this occurs, the rear axle is said to be rotating about the tractor chassis. If the rear axle cannot rotate, then the tractor chassis rotates about the axle (figure 2.58). This reverse action results in the front end of the tractor lifting off the ground until the tractor's CG passes the rear stability baseline. At this point, the tractor will continue rearward from its own weight until the tractor crashes into the ground or other obstacle.

The CG of a tractor is found closer to the rear axle than the front axle. A tractor may only have to raise to about 75 degrees from a level surface before its CG passes the rear stability baseline and the tractor continues flipping over. This position is commonly called the "point of no return." As figure 2.58 shows, this point can be reached more quickly than an operator can recognize the problem.

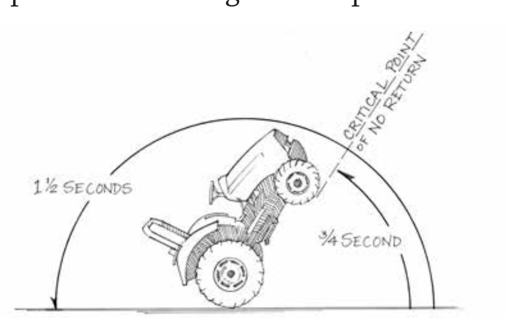


Figure 2.58 The point of no return is reached in ¾ of a second. Credit: J. Mathison.

This type of tractor overturn most often happens when the rear tires are frozen to the ground, the tires are stuck in a mud hole, or the operator has blocked the tires from rotating. Rear overturns can also happen on a slope if an operator applies too much power too quickly to the rear axle. When a tractor is pointed up a slope, there is less rise needed to reach the point of no return because the CG has already moved closer to the stability baseline. Figure 2.59 shows how this occurs.

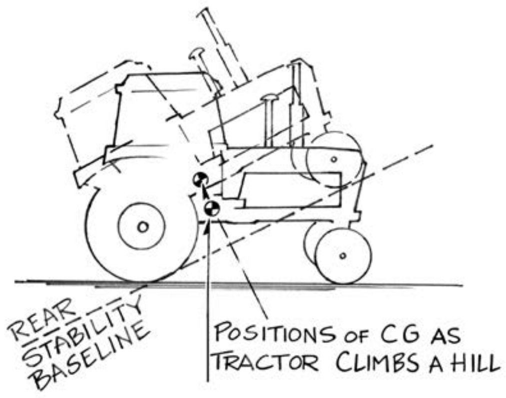


Figure 2.59 When a tractor is pointed up a slope, the CG is closer to the rear stability baseline. Credit: J. Mathison.

When a two-wheel-drive tractor is pulling a load, the rear tires push against the ground. At the same time, the load attached to the tractor is pulling back and down against the forward movement of the tractor. This backward and downward pull results in the rear tires becoming a pivot point, with the load acting as a force trying to tip the tractor rearward. An "angle of pull" is created between the ground's surface and the point of attachment on the tractor.

A tractor and its drawbar (figures 2.60 and 2.61) are designed to safely counteract the rearward tipping action of pulled loads. When loads are attached to a tractor at any point other than the drawbar, the safety design of the tractor for pulling loads is defeated.

The heavier the load and the higher the angle of pull (figure 2.62), the more leverage the load has to tip the tractor rearward.

Figure 2.60 Only hitch to the drawbar. Credit: J. Mathison.

Figure 2.61 Hitch to the 3-point hitch drawbar. Credit: J. Mathison.

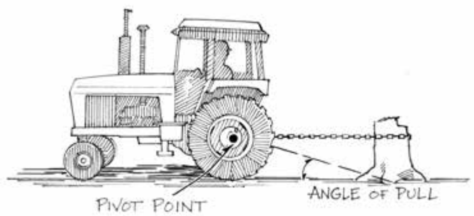


Figure 2.62 The angle of pull should be kept to a minimum. Credit: J. Mathison.

Driver Protection in a Tractor Overturn

The rollover protective structure (ROPS) and seat belt (figure 2.63), when worn, are the two most important safety devices to protect operators from death during tractor overturns. Remember, the ROPS does not prevent tractor overturns, but can prevent the operator from being crushed during an overturn. The operator must stay within the protective frame of the ROPS for the ROPS to work as designed. This means the operator must wear the seat belt.

A ROPS often limits the degree of rollover, which may reduce the probability of injury to the operator. A ROPS with an enclosed cab further reduces the likelihood of serious injury because the sides and windows of the cab protect the operator. This assumes cab doors and windows are not removed.

To prevent tractors from overturning in the first place, follow the safety recommendations illustrated in the next section.

Note: ROPS are available in folding and telescoping versions for special applications, such as orchards and vineyards and low-clearance buildings. Some ROPS may be a protective frame only and not an enclosed cab.

Figure 2.63 A rollover protection structure (ROPS) and a seat belt can protect you in the event of an overturn. If you are in the cab of a ROPS-equipped tractor, fasten the seat belt. Credit: J. Mathison.

Using the Tractor Safely

Tractors can be operated safely if they are used as designed and recommended practices are followed. An estimated 300 farm tractor fatalities occur each year as a result of various types of accidents:

- Teenager killed using tractor to spotlight deer in the woods.
- Man killed when tractor rolled onto him while dragging logs in the woods.
- Grandfather killed, but his passenger, a grandson, lives when the tractor goes over an embankment during a ride.
- Tractor overturns while towing a stalled pickup full of firewood.
- Tractor with its lift bucket raised overturns sideways while traveling across a rough slope.

Proper Use Defined

Tractors are made for work, not to be treated as ATVs, four-wheelers, dune buggies, or as other recreational vehicles (figures 2.64–2.73).

Tractors serve four purposes:

1. They are a remote power source.
2. They carry/pull machines.
3. They move loads.
4. They transport materials.

Consult the operator's manual to determine if a specific use is safe for the tractor.

Proper Use Means Avoiding Improper Use

Figure 2.64 Tractors are designed for the operator only. No passengers allowed! Credit: J. Mathison.

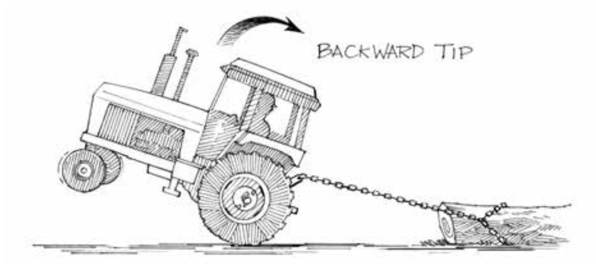


Figure 2.65 Hitch loads only to the drawbar. The drawbar has been engineered to pull heavy loads without risking a rear overturn hazard. Credit: J. Mathison.

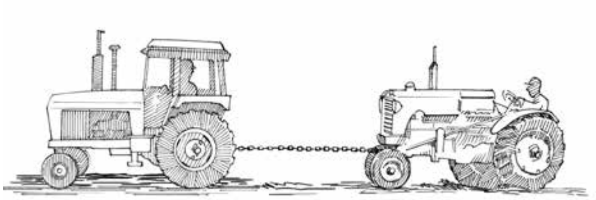


Figure 2.66 If you are stuck or need to be towed, you will need help from a second tractor. Use the strongest and best tow strap, cable, or chain available. Hitch only to the drawbar. The best advice for a young operator is to get adult help to pull the disabled or stuck tractor. Credit: J. Mathison.

Recognize when a driver is operating the tractor in an unsafe manner.

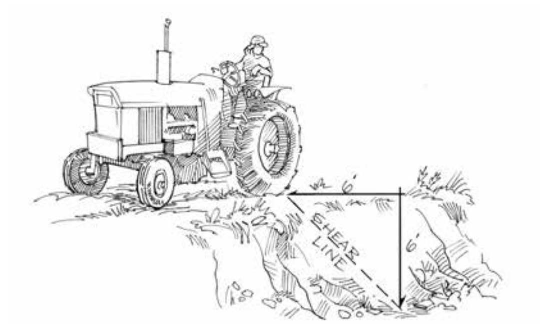


Figure 2.67 Avoid ditch embankments. Tractors are heavy and embankments can give way. For example, if the ditch is 6 feet deep, stay back at least 6 feet. Credit: J. Mathison.

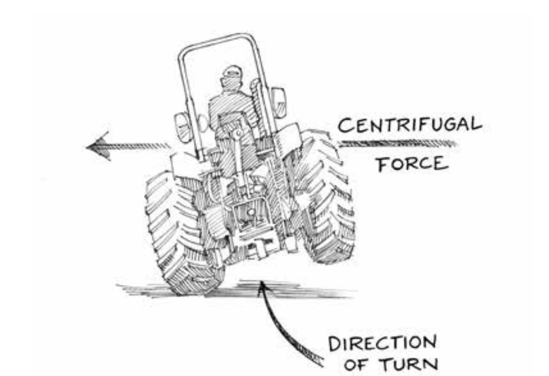


Figure 2.68 Traveling at high speed while making a turn can cause a sideways overturn. Make sure brakes are locked together. Reduce speed before entering the turn. Credit: J. Mathison.

Figure 2.69 Avoid obstacles as you operate the tractor. Some tractor operators will check the field before beginning the operation. Stumps, rocks, animal dens, etc., can upset a tractor. Credit: J. Mathison.

Figure 2.70 Field conditions pose special hazards to tractor operation. The operator must know where these obstacles and depressions are located. Credit: J. Mathison.

Figure 2.71 When operating a high-lift bucket with or without a load, keep the bucket as low to the ground as possible while in transit. Sideways overturns are possible if you travel with the bucket in the up position. Credit: J. Mathison.

Figure 2.72 A tractor stuck in mud is immovable without help. Adult supervision is necessary. Credit: J. Mathison.

Figure 2.73 Be aware of overhead power lines while transporting equipment to avoid risk of electrocution. Credit: J. Mathison.

Operating a Tractor on Public Roads

Today's farmers are traveling more miles than ever before on public roads to plant, grow, and harvest crops. Slow-moving tractors and implements (figure 2.74) are no match for the general public's high-speed travels. Most crashes between farm equipment and motor vehicles occur during daylight and in good weather. Operators must stay aware at all times when traveling on a public road with farm equipment.

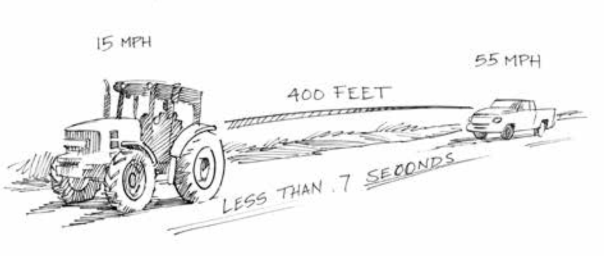


Figure 2.74 An automobile traveling 55 mph will cover the 400-foot distance between the car and the tractor in less than 7 seconds. Will that be enough time or space to slow down or stop to prevent a rear-end crash? Credit: J. Mathison.

Movement Hazards

Traffic hazards are created by the improper operation of tractors on public roadways:

- pulling slowly onto roads with long and heavy loads
- driving the tractor slowly
- turning left across traffic into narrow field lanes
- swinging into the left lane to make a right turn into a field
- transporting wide machinery
- potentially spilling loads

All rules of vehicle safety, as well as all rules of courteous driving, must be followed to prevent traffic problems.

Obeying the Law

Each state has different highway regulations regarding the driver's age requirement and the places where one may operate a farm tractor. States seldom require a driver's license for a tractor, but many do limit 14- and 15-year-old drivers to only crossing over public roadways, or to operating equipment on roads bisecting or adjoining their farm. Check with local state police to learn more about the laws in your area.

Operators must also obey all traffic laws and signs as well.

Tractor operators are at a great disadvantage when traveling on busy highways.

Lighting and Marking

The American Society of Agricultural Engineers (ASAE) standards for lighting and marking (figures 2.75–2.77) are summarized in table 2.4. Most farm equipment delivered from the factory today will conform to these standards. Check to make sure the equipment being used measures up to these standards. If not, learn if the equipment can be improved with retrofit kits of lights and reflectors.

Although not included in the ASAE standard, rotary beacons and back-up alarms are optional accessories, depending upon individual needs. If accessories have been added, they should be in working order.

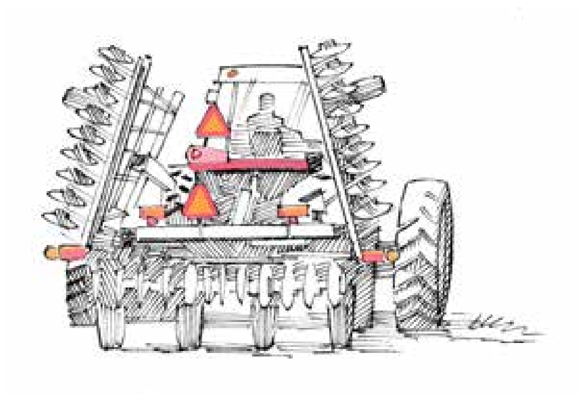


Figure 2.75 The lighting and marking on the equipment you're using may or may not be up to the standards for your state. Check your state laws. Credit: J. Mathison.

Using the proper lighting and marking standards gives motorists ample warning that farm equipment is using the public roadway.

Figure 2.76 Be sure that a work light that points to the rear is off during road travel at night. Single white lights may not be recognized as slow-moving or as a tractor light. Credit: J. Mathison.

Table 2.4. ASAE recommendations for lighting and marking of slow-moving vehicles.

Item	Recommendation
Headlights	Two white lights mounted at the same level
Taillights	Two red lights mounted at the rear
Hazard flashers	Two or more lamps with amber color to the front and red color to the rear
Turn indicators	Two amber to the front and two red lights to the rear mounted with flashers
Slow moving vehicle (SMV) emblem	One visible at 1,000 ft. mounted to the rear and 2–10 ft. above the ground
Reflectors	Two red reflectors (on rear outside corners) and two yellow reflectors (on the front outside corners) of the machine
Conspicuity material	Red retro-reflective and red-orange fluorescent color visible to mark the rear. Yellow retro-reflective material to mark the front.

Figure 2.77 SMV emblems are required on vehicles designed to travel less than 25 mph while occupying public roadways. SMV emblems should be visible from no less than 1,000 feet to the rear of the tractor or towed implement. Therefore, mounting height may vary from 2 to 10 feet above the road surface. Replace faded, damaged SMV emblems. Credit: J. Mathison.

General Practices for Tractors on Highways

Consider the following (figures 2.78–2.80) when traveling on the highway with farm machinery:

- **Time of day**—Is it possible to avoid the busy times of the day to move equipment? Hauling large loads during early morning or late afternoon while people hurry to and from work creates traffic problems for everyone. Moving loads midday or after nightfall may be better timing, but lighting becomes a necessary consideration with the latter.
- **Courtesy**—Try to be as watchful of others as possible. Let the high-speed traffic go first. Use best manners on the highway as the first safe practice to follow.
- **Blind spots**—Are there locations that pose problems with visibility? Avoid them, if possible.
- **Shifting loads**—Any spillage must be cleaned up, from a load of hay, manure, a tank of pesticide mixture, or even mud from the field. The operator is responsible for getting help for cleanup and alerting traffic to be cautious. Know who to notify if manure or chemical spills endanger waterways. There may be reporting requirements with state environmental officials, for example.
- **Safe equipment**—The walk-around inspection prior to starting a tractor should reveal damaged equipment. Be sure damaged equipment does not create a road hazard. For example, a loose wheel on a hay rake could cause a disaster.

Pull completely off the road to let traffic flow past, if possible.
DO NOT SIGNAL THEM TO PASS.
An operator who signals to motorists to pass is responsible for them.

Figure 2.78 A best practice for transporting wide loads on a public roadway is to use an escort vehicle to assist in alerting other motorists. Be a courteous tractor operator to bring good public relations to the farm community. Credit: J. Mathison.

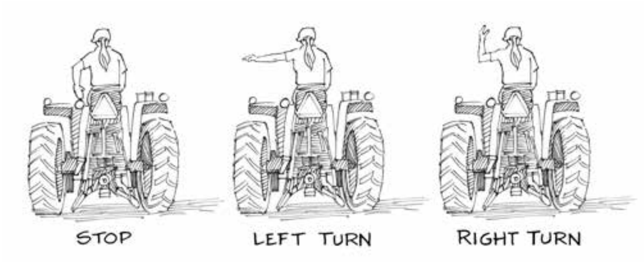


Figure 2.79 Use accepted hand signals to inform other drivers of your intentions. Credit: J. Mathison.

Figure 2.80 Use of public roadways dictates that farm tractors and equipment be visible and identified as slower moving and wider than the usual vehicle traveling the road. Credit: J. Mathison.

Proper equipment marking and lighting on tractors and machinery are necessary for roadway travel.

Is the Equipment Lighting and Marking Adequate?

Highway transport of farm equipment at night requires lighting and marking (figure 2.81). Older equipment must meet these requirements as well. The requirements:

- Slow-speed vehicles display a slow-moving vehicle (SMV) emblem.
- Extremities of width are defined by side marker lights or decals.
- Ability to warn of turns is available using recognizable signals.

If the tractor and equipment or self-propelled equipment does not meet these requirements, operators increase the risk of injury to themselves and others.

Figure 2.81 Can you identify the lighting and marking features used on this tractor and grain drill? No. 1 is__________. No. 2 are __________. No. 3 represents____________. Is the equipment safely marked for roadway travel? Credit: J. Mathison.

To see another set of suggested tractor safety activities, visit **progressiveag.org**.

ACTIVITY 2.1

Tractor Hazards

LEADER NOTES

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Understand why working with tractors can be dangerous and how to stay safe around them.

Education Standard(s): **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–3 below. Youth can summarize why working with tractors can be dangerous and how to stay safe around tractors.

Life Skills: Empathy, analysis, research

Tags: Farm safety, tractor safety

Time Needed: 1–2 hours

Materials List:

- farm magazines and/or local or regional newspapers
- copies of Let's Do It!
- pens/pencils
- computer(s) with internet connectivity (optional, for part 1 and for part 2 variation)
- video camera (optional, for part 2 variation)

Space: Classroom or other indoor space

Suggested Group Size: Maximum of five per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: See the Variations section below to decide how you want to present the activities. If you invite a farmer to tell about a tractor incident, be sure they will communicate positive safety messages about how to avoid similar incidents.

Arrange for the group to meet at a farm and do a safety tour.

Variations:

For part 1, youth could work together to summarize the incident described in one article.

For part 2, you could record the farmer on video if it's inconvenient to schedule a visit to the group in person.

Introduction: Review the sections Tractor Types and Sizes and Purposes, and Youth and Tractors in Chapter 2.

Opening Questions: What are some possible dangers in operating or being around a tractor? What types of injuries are most common from tractor use? What are some ways we can stay safe around tractors?

ACTIVITY 2.1

Tractor Hazards

LET'S DO IT!

1. Collect newspaper articles on farm tractor accidents, preferably from your local area, or use the internet. Summarize the main points and what you can learn from the articles. Share with the group in a presentation.

2. Listen to a farmer tell a story of someone injured in a tractor incident. (These arrangements will be made in advance by your leader.) Discuss the story. What danger does the story point out? How can it be avoided?

3. With a knowledgeable supervisor, conduct a safety tour of a farm/farm shop/tractor shed to identify hazards and safety issues as well as positive points of safety related to equipment and tractors. Summarize your findings here.

Terms: Using what you learned above, define the following terms in your own words.

Power takeoff (PTO):

Rollover protection structure (ROPS):

Reference:

Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More:

Penn State Farm Safety: **extension.psu.edu/business/ag-safety**

Ag Youth Work Guidelines from the National Children's Center for Rural and Agricultural Health and Safety: **cultivatesafety.org/work**

USDA, National Institute of Food and Agriculture: **nifa.usda.gov/program/farm-safety**

ACTIVITY 2.2

Introduction to the Tractor Instrument Panel and Controls

LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Understand instruments, gauges, and controls that monitor tractor operation and performance. Make operating decisions based on information from tractor gauges. Understand color-coding of tractor controls.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1 and 2 below and can summarize the basic functions of instruments, gauges, and controls that monitor tractor operation and performance, make operating decisions based on information from tractor gauges, and understand color-coding of tractor controls.

Life Skills: Analysis, decision making, beginning tractor operation

Tags: Introduction to tractor, instrument panel, tractor controls, tractor operation

Time Needed: ~1 hour, depending on the experience of students and the number of tractors and instructors available

Materials List: Access to at least one tractor, preferably two, one with an automatic transmission and one with a manual transmission. These should be medium sized (~35-50 HP) with wide front-end wheels, an ROPS, and a seat belt.

Space: Classroom or other indoor space for quiz. Barn, garage, or tractor storage area for part 2.

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Introduction: Review the Tractor Instrument Panel and Tractor Controls sections of Chapter 2.

Opening Questions: How might you go about learning to drive a tractor? There are dozens of kinds of tractors out there. Do they have any controls in common?

LET'S DO IT!

ACTIVITY 2.2

Introduction to the Tractor Instrument Panel and Controls

Part 1 Quiz:

1. If you are operating the tractor in the field and the oil light comes on, what should you do?
   A. drive to the shop
   B. stop and let the engine idle
   C. shut down immediately
   D. shut off the engine until it cools and then restart
2. What can happen if you remove a radiator cap from an overheated tractor's coolant system?
   A. nothing
   B. explosive pressure can hurt you
   C. a fire may start
   D. you can be scalded by hot steam
3. The letters rpm represent:
   A. ground speed measurement
   B. oil pressure measurement
   C. engine speed measurement
4. When pulling a heavy load of hay up a hill, which gear/rpm combination should you use?
   A. 5th gear/high rpm
   B. lower gear with medium rpm
   C. highest gear with lowest rpm
5. Match the tractor function with the color you would expect the control to be.

______	Engage PTO	A. Red
______	Lift a high-lift bucket	B. Orange
______	Throttle up	C. Yellow
______	Stop a diesel engine	D. Black

Part 2: Identify as many specific controls as you can on one or more tractors, and group them by control function.

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Concept Discovery: Tractor controls with similar functions are color-coded. How does this help when you are learning to drive a tractor or driving a new tractor?

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Term: Using what you learned above, define the following term in your own words.

Tachometer:________________________________

____

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 2.3

Engine Stop Controls

LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Identify tractor engine stop controls used on modern tractors by their color. Understand how movement of engine stop controls affects the tractor.

Education Standards: **CRP.01**. Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1 through 3, identifies tractor engine stop controls used on modern tractors by their color, and understands how movement of engine stop controls affects the tractor.

Life Skills: Analysis, decision making, beginning tractor operation

Tags: Introduction to tractor, tractor controls, engine stop controls, tractor operation

Time Needed: 45 minutes, not including travel time (if needed), depending on experience of students and number of tractors and instructors available

Materials List:

- a gasoline engine tractor
- a diesel engine tractor equipped with a medium sized ~35-50 HP, wide front-end wheels, an ROPS, and a seat belt.
- an older tractor
- pens/pencils
- copies of Let's Do It!

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange to have a diesel engine tractor and a gasoline engine tractor for the youth to explore. Locate some old tractors in your area and arrange for the youth to visit one of them.

Introduction: Review the sections Tractor Controls and Engine Stop Controls in Chapter 2.

Opening Questions: "How do I stop the engine?" This routine operation can be tricky the first time you operate a tractor, or when you learn to operate a tractor new to you. This activity will teach you to use the color-coding common on many tractors to help answer this question, and help you understand the operating differences between diesel- and gasoline-powered tractors.

ACTIVITY 2.3

Engine Stop Controls

LET'S DO IT!

1. Be sure the tractors are turned off and not running for this activity. Compare the ignition switch and stop engine control methods of diesel and gasoline engine tractors by tracing the wiring of each. Review how each type is turned on and off. Summarize the main differences you observe.

2. Find the oldest tractor you can in your community and determine if color-coding indicates how to stop the engine. Record the tractor model, its approximate age, and whether color-coding helps to find the engine stop controls.

3. Name three ways you can learn how to operate a tractor unfamiliar to you. List advantages and disadvantages of each way.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 2.4

Ground Motion Controls, Power Engagement Controls, and Positioning/Adjusting Controls

LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Identify by color tractor ground motion controls, power engagement controls, and positioning/adjusting controls used on modern tractors. Understand how movement of the various controls affects the tractor.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4 and can identify controls by their color, including tractor ground motion controls, power engagement controls, and positioning/adjusting controls. Youth understands how movement of these controls affects the tractor.

Life Skills: Analysis, memory, beginning tractor operation

Tags: Introduction to tractors, tractor ground motion controls, power engagement controls, positioning/adjusting controls, tractor operation

Time Needed: 1–1.5 hours

Materials List:

- If possible, provide at least two diesel engine tractors and one gasoline engine tractor. These should preferably be medium sized (~35–50 HP) with wide front-end wheels, an ROPS, and a seat belt. Point out safety features when you start the activity.
- pens/pencils and paper
- copies of Let's Do It

Space: Tractor display showroom, barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange to have at least two diesel tractors and one gas tractor available for the youth to explore. It's helpful to have at least one older tractor and one modern one. If a gasoline tractor is not readily available, consider using a third diesel tractor that is of a different age or size than the other two diesel tractors.

Introduction: Review the sections Ground Motion Controls, Power Engagement Controls, Positioning/Adjusting Controls, and Location and Movement of Tractor Controls in Chapter 2.

After the youth have thoroughly explored the various tractors and experimented with moving the controls, randomly ask them to identify the name and purpose of various controls on each tractor.

Opening Questions: "How do I get this tractor to move?" "How do I stop this operation?" "How do I get this implement to run?" "Where is the PTO control for this tractor?" "How do I adjust the steering column and the seat?" These are all questions first-time tractor operators have, as well as experienced operators who are using tractors new to them. You can always find the answers by checking the operator's manual. The activities here will help you use the traditional color-coding system for controls to understand how to operate any modern tractor.

ACTIVITY 2.4

Ground Motion Controls, Power Engagement Controls, and Positioning/ Adjusting Controls

LET'S DO IT!

1. Be sure the tractors are off and not running. Explore the tractors provided. Note the orange color-coded controls. What does each control do?

____

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   Identify and list as many ground motion controls as you can on several different tractors. Compare their locations and their direction of movement.

   ____

   ____

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   ____

2. Now note the yellow color-coded controls. What does each control do?

____

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Identify and list as many power engagement controls as you can on the different tractors. Compare their locations and their direction of movement.

3. Now note the black color-coded controls. What does each control do?

Identify and list as many positioning/adjusting controls as you can on the three different tractors. Compare their locations and their direction of movement.

4. Give as many reasons as you can for how color coding of tractor controls improves tractor operation safety.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 2.5

Tractor Operation Symbols and Preventive Maintenance I

LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Recognize the messages that tractor operation symbols convey during normal tractor use and possible malfunction. Learn the importance of conducting preventive maintenance to reduce repair costs and downtime. Learn how to do some basic preventive maintenance checks and tasks.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–3, recognizes the messages that tractor operation symbols convey during normal tractor use and possible malfunction, understands the importance of conducting preventive maintenance to reduce repair costs and downtime, and learns how to do some basic preventive maintenance tasks.

Life Skills: Analysis, memory, beginning tractor operation, beginning tractor maintenance

Tags: Introduction to tractors, tractor operation, tractor operation symbols, preventive maintenance, oil change

Time Needed: 1 hour, depending on experience of students and number of tractors and adult helpers available

Materials List:

- pens/pencils
- copies of Let's Do It!
- materials for tractor oil change and filter change (e.g., pan for collecting old oil, oil filter removal tool, spout for pouring new oil, rag for wiping minor spills/drips, sufficient new oil, new oil filter, gloves)
- at least one tractor that needs an oil change

Space: Classroom or other indoor space for parts 1 and 2; barn, work shed, or farmyard for part 3

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Variations: Quiz question 1: You could quiz youth by showing them operation symbols directly on the tractor.

Introduction: Review the Tractor Operation Symbols; Preventive Maintenance and Pre-Operation Checks; and Fuel, Oil, and Coolant Levels sections of Chapter 2.

Opening Questions: There is increasing diversity among agricultural workers today. How might someone who doesn't read English learn about the hazards of tractor operation? (There are also videos and publications specifically for Spanish speakers, such as: **youtube.com/playlist?list=PL8hJRvD_GIH6m0dWZooJWqxtUJXP1jrga**) This activity introduces some symbols important in tractor operation and maintenance. What can happen if a tractor isn't properly maintained?

ACTIVITY 2.5

Tractor Operation Symbols and Preventive Maintenance I

LET'S DO IT!

Part 1 Quiz

1. List five operating symbols that are important to locate and respond to before you start a tractor (choose any from the ones discussed). Why is each symbol important?

2. You are raking hay in a field 1 mile from the farm shop. The engine coolant level light comes on. Draw the symbol for that malfunction below.

What should you do? (Circle appropriate answer.)

A. drive it back to the farm shop

B. continue to rake hay

C. shut down immediately

D. let the tractor idle while you use your cellphone to notify the owner of the tractor

3. A tractor you are using begins to show a low-battery charge problem. Draw the symbol for that malfunction in the box provided.

   What should you do? (Circle appropriate answer.)

   A. return to the shop area and turn off the tractor

   B. shut down immediately

   C. return to the shop area but leave the tractor running until problem is diagnosed

   D. none of these

Part 2

Make a chart of maintenance tasks to be done on the tractor you'll use. Use the following format, or develop your own chart. If you have a computer, make a spreadsheet or database to help with maintenance records.

Date	Tractor maintenance item	Problem found	Corrective action

Part 3

Help someone change the oil and oil filter on a tractor. Afterward, summarize the steps and key safety tips for this job.

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Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Be sure the tractors are off and not running. Explore the tractors provided. Note the orange color-coded controls. What does each control do?

____

____

____

ACTIVITY 2.6

Tractor Preventive Maintenance II

LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Recognize the messages that tractor operation symbols convey during normal tractor use and possible malfunction. Learn the importance of conducting preventive maintenance to reduce repair costs and downtime. Learn how to do some basic preventive maintenance checks and tasks.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–3, recognizes the messages that tractor operation symbols convey during normal tractor use and possible malfunction, understands the importance of conducting preventive maintenance to reduce repair costs and downtime, and learns how to do some basic preventive maintenance tasks.

Life Skills: Analysis, memory, beginning tractor operation, beginning tractor maintenance

Tags: Introduction to tractors, tractor operation, tractor operation symbols, preventive maintenance, oil change

Time Needed: 1 hour, depending on experience of students and number of tractors and adult helpers available

Materials List:

- pens/pencils
- copies of Let's Do It!
- materials for tractor oil change and filter change (e.g., pan for collecting old oil, oil filter removal tool, spout for pouring new oil, rag for wiping minor spills/drips, sufficient new oil, new oil filter, gloves)
- at least one tractor that needs an oil change

Space: Classroom or other indoor space for parts 1 and 2; barn, work shed, or farmyard for part 3

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Variations: Quiz question 1: You could quiz youth by showing them operation symbols directly on the tractor.

Introduction: Review the Tractor Operation Symbols; Preventive Maintenance and Pre-Operation Checks; and Fuel, Oil, and Coolant Levels sections of Chapter 2.

Opening Questions: There is increasing diversity among agricultural workers today. How might someone who doesn't read English learn about the hazards of tractor operation? (There are also videos and publications specifically for Spanish speakers, such as: **youtube.com/playlist?list=PL8hJRvD_GIH6m0dWZooJWqxtUJXP1jrga**) This activity introduces some symbols important in tractor operation and maintenance. What can happen if a tractor isn't properly maintained?

ACTIVITY 2.6

Tractor Preventative Maintenance II

LET'S DO IT!

1. Memorize the pre-operation checklist (see below) and recite it as you conduct a pre-operation inspection of a tractor. Note any problems you find.

Tractor Pre-Operation Checklist	
Date	**Item (identify and explain what you are inspecting)**
	Check fluid levels (oil reservoir dipstick; fuel tank cap; water/antifreeze fill location; hydraulic fluid dipstick, etc.)
	Battery condition
	Tire condition (tractor and implements)
	Guards and shields (tractor and implements)
	Hitch and related connections
	Walk around tractor and implements and look for hazards

2. Call a tractor dealer's service department to ask about the cost to rebuild a tractor engine damaged from lack of oil (only one or two people should do this). Provide this information to the group.

3. Using a hydrometer (a device that measures specific gravity of coolant or antifreeze for the level at which the liquid would freeze), test a tractor's engine coolant for the temperature protection that coolant would provide.

4. Describe the difference between diesel fuel and gasoline. How does storage of these fuels differ? (You may need to do a little internet research to find out.)

5. Help someone change the air filter on a tractor. Afterward, summarize the steps and key safety tips for this job.

6. Have a seasoned user show you how to check air pressure in a calcium-filled tractor tire. Afterward, summarize the steps and key safety tips for this job.

7. Select a tractor at the farm where you work and check for items on the steps and operator platform. Remove them to a safer place and note here what you find.

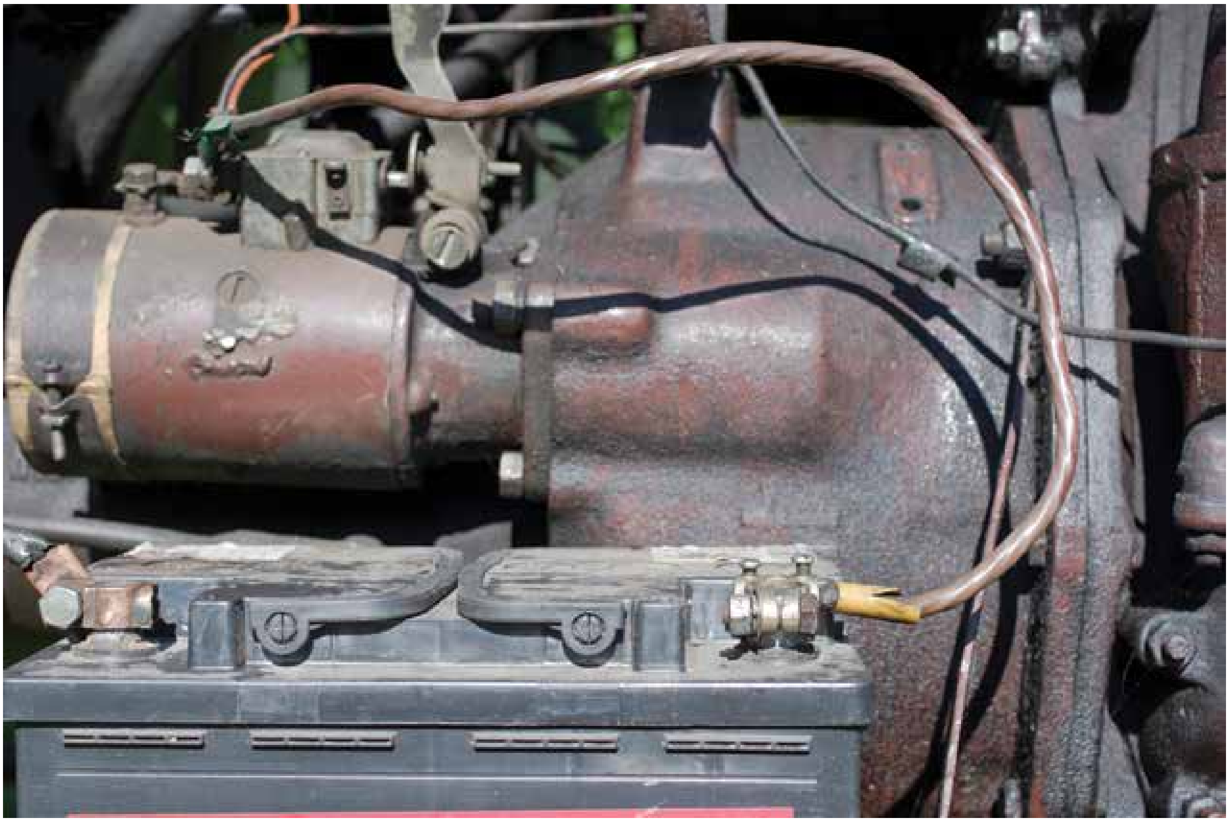
Term: Using what you learned above, define the following term in your own words.

Oil viscosity:

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 2.7

Tractor Batteries



LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Identify battery parts and functions, become familiar with hazards of lead acid batteries, use safe practices in working with batteries, safely use a battery charger and jumper cables on a weak battery.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4, identifies battery parts and functions, becomes familiar with hazards of lead acid batteries, uses safe practices in working with batteries, and safely uses a battery charger and jumper cables on a weak battery.

Life Skills: Memory, beginning tractor operation, beginning tractor maintenance

Tags: Introduction to tractors, preventive maintenance, batteries

Time Needed: ~1 hour

Materials List:

- pens/pencils
- copies of Let's Do It!
- safety glasses
- rubber gloves
- long-sleeved clothing
- weak battery to be charged
- approved battery charger
- battery terminal cleaner or a mixture of baking soda and water
- approved jumper cables of 4-, 6-, or 8-gauge wire
- wrenches
- booster battery, usually from another tractor or vehicle

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Introduction: Review the Lead Acid Batteries, Using a Battery Charger, and Using Jumper Cables sections of Chapter 2.

Variations: Watch internet videos of the activity operations if you can't do them first-hand. As suggestion in previous activities, watch videos from different sources to get a complete and accurate picture.

Opening Questions: It's 7 a.m. on a picture-perfect hay-making day and the tractor won't start. How do batteries help start tractors? How do you use a battery charger or jumper cables on a tractor?

ACTIVITY 2.7

Tractor Batteries

LET'S DO IT!

1. With an experienced adult, check the fluid (electrolyte) level in your family's car, truck, riding mower, or tractor if it has fluid fill caps. If there are no fill caps, observe how the battery is checked for electrolyte. Use eye and skin protection.
2. With an experienced adult, clean the battery terminals of a corroded battery by removing the battery cables (ground cable first, and positive or "hot" cable last). Use eye and skin protection. Use a battery terminal cleaner or mixture of baking soda and water. Re-attach battery cables with the "hot" or positive first and the ground cable last.
3. With an experienced adult, use a battery charger to charge a weak battery. Use eye and skin protection.
4. With an experienced adult, use booster cables to boost a weak battery.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 2.8

Safely Starting and Stopping Tractor Engines

LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Safely start and stop the engine of a gasoline and a diesel tractor. Understand the differences between gasoline and diesel engines. Know and use safe tractor mounting and dismounting procedures.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4, safely starts and stops the engine of a gasoline and a diesel tractor, understands the differences between gasoline and diesel engines, and knows and uses safe tractor mounting and dismounting procedures.

Life Skills: Memory, comprehension, beginning tractor operation

Tags: Introduction to tractors, beginning tractor operation

Time Needed: ~1 hour

Materials List:

- pens/pencils
- copies of Let's Do It!
- tractors, preferably one diesel and one gasoline, preferably medium sized (~35-50 HP) with wide front-end wheels, an ROPS, and a seat belt
- computer with internet connectivity (optional, for variation)

Space: Classroom or other indoor space is ideal for part 1; barn, work shed, or farmyard for part 2

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Introduction: Review the Starting and Stopping Diesel and Gasoline Engines, Mounting and Starting the Tractor, and Stopping and Dismounting the Tractor sections of Chapter 2.

Variations: If you can't arrange hands-on practice for the youth in your group to start and stop a tractor, watch this video from the University of Wisconsin Extension. **youtube.com/watch?v=KYmwW80gqLU&feature=youtu.be**

Opening Questions: After all this, you're probably eager to actually start up a tractor, right? But how do you actually do that? What are the differences between starting a gasoline and a diesel engine tractor?

LET'S DO IT!

ACTIVITY 2.8

Safely Starting and Stopping Tractor Engines

Part 1: Quiz

1. True or False: Gasoline engines do not give off dangerous fumes.

2. Choking an engine to start it on a cold morning means (circle correct answer below):
   A. Holding the key in the start position for as long as it takes.
   B. Providing more fuel for better ignition.
   C. Gassing the engine by pumping the throttle.
   D. Pouring extra fuel into the air cleaner to start the engine.
3. Diesel engines do not have spark plugs. How is diesel fuel ignited in the cylinder?

____

____

____

4. Why should a cold engine be allowed to warm up before pulling a heavy load?

____

____

____

5. What can happen to the tractor's parts if you crank the starter motor too long?

____

____

____

6. True or False: Diesel engines do not give off carbon monoxide.

____

7. True or False: Diesel engines give off carbon dioxide gases.

____

8. What is the name of the lethal gas given off by a gasoline engine? (circle correct answer below)

   a. Carbon dioxide   b. Carbon trioxide   c. Carbon monoxide

9. Where are glow plugs found, and what do they do?

____

Part 2: Practice

1. With an experienced adult, practice starting and stopping gasoline and diesel tractor engines.
2. Practice safe tractor mounting and dismounting and explain the key steps as you do each.
3. Explain the dangers of bypass starting.

____

____

Term: Using what you learned above, define the following term in your own words.

Bypass starting:____

____

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 2.9

Tractor Stability

LEADER NOTES

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Explain the role that center of gravity plays in tractor overturns. List reasons the center of gravity moves within the stability baseline. Explain how to be protected during a tractor overturn.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–3 and can explain the role that center of gravity plays in tractor overturns, list reasons the center of gravity moves within the stability baseline, and explain how to be protected during a tractor overturn.

Life Skills: Comprehension, beginning tractor operation, safety, public speaking, math

Tags: Introduction to tractors, beginning tractor operation, rollover protection structure, safety

Time Needed: 1 hour, not including travel time

Materials List:

- pens/pencils
- copies of Let's Do It!
- toy tractors
- camera or video recorder (optional, for variation to part 3)

Space: Classroom or other indoor space

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Identify some farms where the youth could conduct the tractor survey, and brainstorm some folks who may have a tractor incident story to tell.

Variations: For part 3: You could use a camera or video recorder to document unsafe farm situations and/or people telling their tractor rollover stories.

Introduction: Review the Tractor Stability and Using the Tractor Safely sections of Chapter 2.

Opening Questions: Nearly 50% of tractor fatalities come from tractor overturns. The versatility of tractors means that sometimes they are used for tasks that they really shouldn't be. Can you think of a time you've seen a tractor being used in what was or seemed like an unsafe manner? What kinds of stories have you heard about tractor incidents? Discuss.

LET'S DO IT!

ACTIVITY 2.9

Tractor Stability

1. Use a toy-scale model to illustrate the five main reasons why tractors overturn.
2. Conduct a survey of tractors at area farms. Make a table to show the number with rollover protection structures (ROPS); their horsepower; their age; and the type of transmission (manual or automatic). Calculate percentages.
3. Conduct a survey of area farm people to find instances of tractor overturns in the last five years. How many overturns resulted in a fatality? How many survived an overturn? Did a ROPS play a role in their survival? Calculate percentages. You could make a display for the group or the county fair (keep people's identities private).

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 2.10

Practice Driving a Tractor

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Drive a tractor without stalling or jerking with proper use of the clutch control pedal or lever. Steer a tractor without damaging the tractor or other property.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4, drives a tractor without stalling or jerking properly using the clutch control pedal or lever, and steers a tractor forward and reverse without damaging the tractor.

Life Skills: Memory, comprehension, beginning tractor operation, driving, steering

Tags: Introduction to tractors, beginning tractor operation, driving, steering

Time Needed: 1 hour, depending on experience of students and number of tractors and instructors available

Materials List:

- pens/pencils
- copies of Let's Do It!
- tractors, preferably one diesel and one gasoline, with operator's manuals, preferably medium sized (~35-50 HP), with wide front-end wheels, an ROPS, and a seat belt
- cones or other markers for tractor driving course

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Scout out an open, flat area for beginning tractor driving. Also, plan out a challenging course for the youth to try once they've gained experience in the open, flat area. See **paffa.org/page.aspx?ID=406** for the Pennsylvania FFA tractor/equipment driving course and information. Alternatively, you may refer to the National Safe Tractor and Machinery Operation Program (NSTMOP) tractor skills and driving test layout map at the end of this activity.

Point out the tractor's safety features before you start the activity.

Variations: If you absolutely can't get hands-on practice, watch the videos from the University of Wisconsin Extension at **fyi.uwex.edu/tractorcert/2015/01/10/new-videos**. Even if you can practice driving, it would be helpful to watch the videos to see if you can pick up some tips.

Introduction: Review the Moving and Steering the Tractor, Operating a Manual Shift Transmission, Other Tractor Transmissions, and Operating the Tractor in Reverse sections of Chapter 2.

Opening Questions: And finally, we get to drive a tractor! Driving a tractor involves many skills and decisions—knowing how to start, stop, and steer the tractor, and how and when to shift gears, and later how to hitch implements and drive with them. It's not a simple task and it's going to take some time to develop the skill to drive smoothly, especially if you've never driven a car. How many of you have already driven a tractor? What kind and size of tractor was it? Did someone teach you how to operate it safely? Let's get to it!

LET'S DO IT!

ACTIVITY 2.10

Practice Driving a Tractor

1. Review the operator's manual of the tractor you will practice driving. Refer to the manual when you have questions as you go. Being familiar with the manual will help you find the information you need when no qualified operator is available to assist you.

2. On newer tractors, use the operator's manual to locate information that would tell you what speed and power setting to use for various field operations.

Field work to be done	Transmission setting	Engine rpm
Light load	____________________	____________
Heavy load	____________________	____________

Parts 3–5 should be done in a large, flat open area where there is no danger of the tractor rolling.

3. Review where the ground motion controls (clutch, gear shift pattern, shuttle shift and/or shift lever) are on the tractor you'll be driving. Without starting the tractor, push in on the clutch pedal and practice shifting the gears. With the tractor still off, practice pushing the clutch all the way in and then releasing it slowly to get the feel of the clutch pressure.

4. Practice starting the tractor, putting it in gear, and moving it slowly in a figure-eight pattern.

5. Once you have the hang of moving forward smoothly, try steering the tractor in reverse, first in a straight line, and then slowly in a figure eight. Use a low-range gear and a low-speed throttle adjustment.

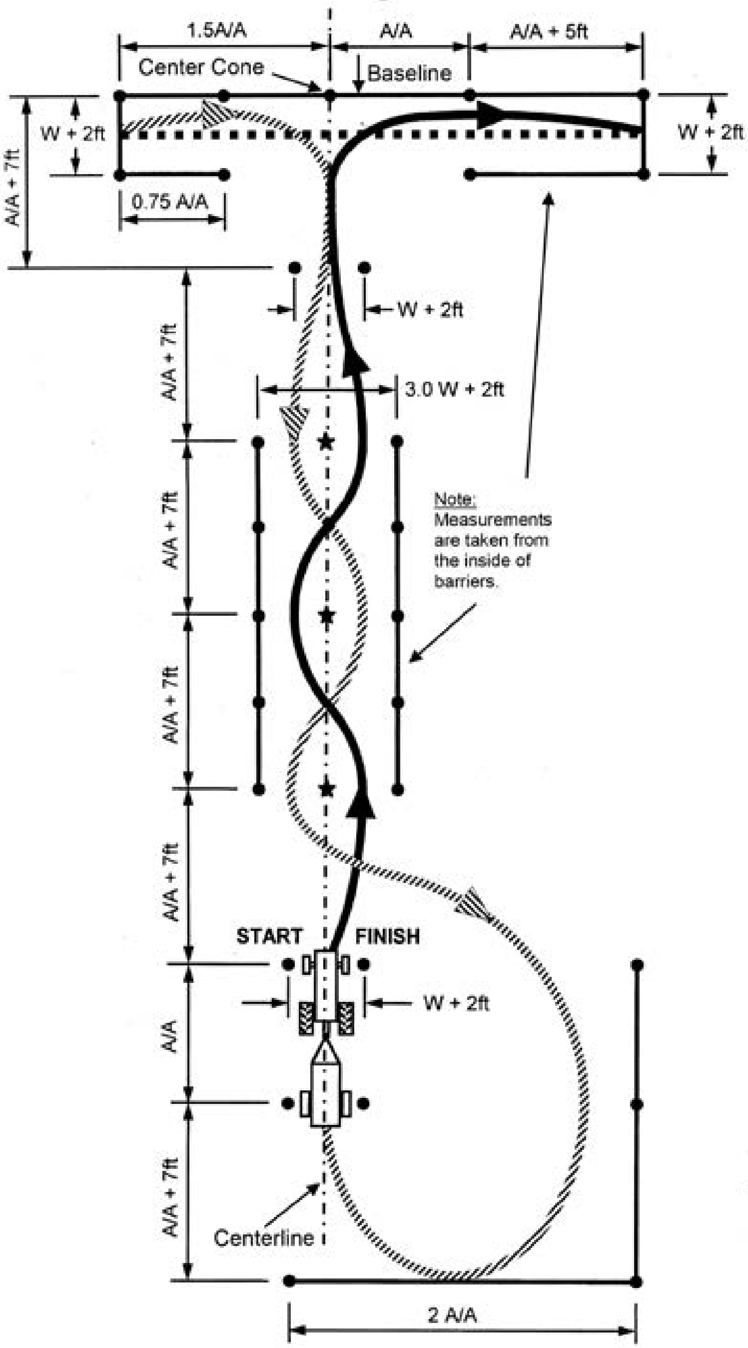
Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

National Safe Tractor and Machinery Operation Program

Student Manual

Skills and Driving Test Layout Map

Driving Test



Calculations

A/A	=	________
2 A/A	=	________
1.5 A/A	=	________
.75 A/A	=	________
A/A + 5	=	________
A/A + 7	=	________
W	=	________
W + 2	=	________
3 W + 2	=	________
Length 7 A/A + 42	=	________
Width 3.5 A/A + 5	=	________

★ — Use traffic cones, stakes, buckets, etc. to identify serpentine path

● — Use traffic cones, stakes, straw or hay, etc. as markers.

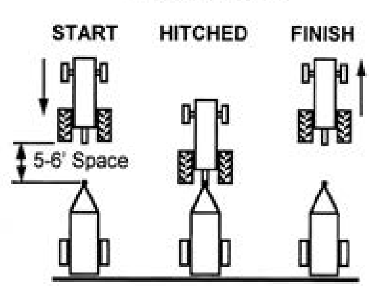
| — Use rope, baler twine, straw or hay bales to form a continuous line.

Start path
Back-up path
Return path

A/A — Means axle to axle. The distance between center of front axle of tractor and center of axle of towed equipment.

W — Width in feet of the tractor or two-wheel towed equipment, whichever is wider.

Skills Test



Note: Raise or lower implement 3 or 4 inches before starting.

Version 2.March 2013

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ACTIVITY 2.11

Tractors on Public Roads

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Understand the difference between farm equipment road use and normal highway vehicle road use. Use all safe and courteous traffic driving practices to prevent equipment and motor vehicle crashes.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4, understands the difference between farm equipment road use and normal highway vehicle road use, and uses all safe and courteous traffic driving practices to prevent equipment and motor vehicle crashes.

Life Skills: Comprehension, tractor operation, safety, math

Tags: Tractor operation, safety, public roads

Time Needed: 1 hour

Materials List:

- pens/pencils
- copies of Let's Do It!
- calculator(s) or the calculator function on a smart phone (optional)
- tractor, preferably medium sized (~35-50 HP), with implement in tow, wide front-end wheels, an ROPS, and a seat belt
- tractors and implements in a farmyard
- 25- or 50-foot measuring tape

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Invite a local police officer or farm bureau representative to discuss with the group the laws relating to operating a tractor on public roads. This can help increase the safety of operators and build connections between law enforcement and the farming community.

Identify a farm on which the youth could check compliance of tractor and implement lighting with state regulations.

Introduction: Review the Operating the Tractor on Public Roads, and Lighting and Marking sections of Chapter 2.

Opening Questions: How many fields on the farm where you will or do work require you to cross the road from the main work shed, or to travel on public roads with farm equipment?

ACTIVITY 2.11

Tractors on Public Roads

LET'S DO IT!

1. After listening to the presentation about tractor operation on public roads, discuss with the group any concerns you still have about this topic or any aspects that seem unclear to you.

2. Measure the length of the longest tractor and implement combination with which you will work. Then measure out a 24-foot space in an open flat area. This represents the width of a typical two-lane rural road. Time how many seconds it takes your leader to drive the tractor and towed implement the 24 feet. __________ seconds.

   A car approaching the farm driveway is traveling at 60 mph. How many feet will that car travel in 1 second? __________ feet

   Hint: 60 mph =1 mile/minute Calculate what distance in feet will be covered in 1 second.

   Remember that 5,280 feet equals 1 mile.

   1 mile/minute = __________ feet/second.

   Multiply the answer (feet/second) in question 2 by the time you recorded in question 1. This is the distance the car going 60 mph will travel in the time it takes you to cross a 24-foot-wide road with your tractor and implement. Record the answer here. ________ Can you see that far as you pull out to cross the roadway? ____________ If not, what are two strategies you could use to make that area safer? ______________________________

____

____

____

____

3. Conduct a survey of the lighting, marking, and hitching of the tractors and towed implements on your farm or farm of employment. Does it meet the safety requirements of your state?
4. Practice the hand signals for right, left, and stop that you will use while operating a tractor not equipped with turn signals.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Chapter 3 Connecting and Using Implements with Tractors

Please see the Note to Leaders at the front of the book for some important safety and logistics considerations.

Imagine this scenario: A supervisor expects a worker to hitch the rake to the tractor and be in the nearby field within 5 minutes. After 10 minutes, the worker can't seem to get the drawbar of the tractor lined up with the hitch on the rake.

Can the worker steer in reverse? Can they use the clutch and brakes smoothly? If not, they could review the information in Chapter 2 on steering in reverse and moving and steering the tractor.

Do they understand where to hitch to the load to ensure tractor stability? If not, they should review the information on tractor stability toward the end of Chapter 2.

This section provides an overview of safely and efficiently hitching implements to the tractor.

Hitching and the Center of Gravity

Chapter 2 described the tractor's center of gravity and stability baseline. Tractor hitches are designed so the downward and rearward force during a pull are below the center of gravity. To maintain tractor stability, the "angle of pull" should be kept as low as possible by hitching loads only to the drawbar.

Pulling a load with the downward and rearward force above the tractor's center of gravity will result in a rear overturn (figure 3.1). Hitch only to the drawbar to prevent the tractor from rearing up and turning over (figure 3.2). Even small lawn and garden-size tractors can flip rearward if not properly hitched to a load.

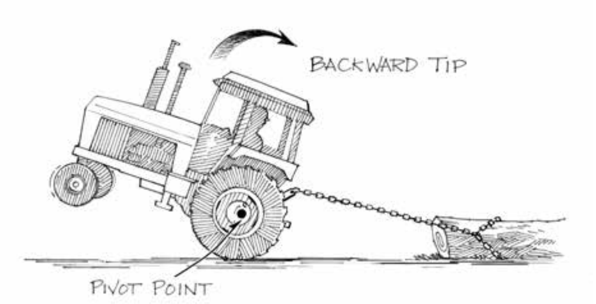


Figure 3.1 The log is fairly immovable. A chain hooked above the center of gravity of the tractor (e.g., top of 3-point hitch bracket) allows a rearward tip of the tractor. Improper hitching can override safe tractor engineering design. Many people have lost their lives this way. Credit: J. Mathison.

Figure 3.2 The tractor drawbar is the only safe place to connect a load. Do not hitch higher than the drawbar so all pulling forces stay below the tractor's center of gravity. For most operations the drawbar should be placed midway between the rear tires to maximize pulling power. Hillside operations may require a drawbar adjustment to one side to balance the pulling forces. Credit: J. Mathison.

A bolt laying around the farm shop is not a substitute hitch pin! Hitch pins are designed for specific drawbar loads and power ratings and must fit the drawbar hole.

Drawbar and 3-Point Hitching

Implement Hitching

Follow these steps for *hitching to a drawbar*.

1. Position the tractor to align the hole in the drawbar with the hole in the implement hitch. This is called spotting. This skill requires practice.
2. Stop the engine, put the tractor in park (if available), and set the brakes.
3. Attach the implement using the proper-sized hitch pin and security clip.
4. Raise the implement jack stand and remove chock blocks from the wheels.
5. Connect the PTO shaft, hydraulic hoses, and/or electrical connections as required. Refer to Chapter 2 as needed.

Follow these steps for *hitching to a 3-point hitch attachment* (figures 3.3, 3.4, and 3.5). For more information, see Chapter 2.

1. Move the stationary tractor drawbar forward for clearance.
2. Position the tractor so the pin holes of the draft arms are closely aligned with the implement hitch points.
3. Raise or lower the draft arms to match the implement hitch points.
4. Stop the engine, put the tractor in park (if available), and set the brakes.
5. First, attach the left draft arm to the implement hitch point using the proper-sized hitch pin and security clip. The right arm is adjustable and is connected next.
6. Remount and start the tractor to use the hydraulic system to raise the lift arms, if needed.
7. Match the top link of the 3-point hitch to the implement's upper hitch point. Raise

the lift arms to lengthen, or drive ahead with implement down to shorten for adjustment, if needed. The implement may not be level if the upper link has been adjusted too many times. If it is out of level, the machine may not work properly.

If the machine cannot be leveled, ask for help or check the operator's manual. The manual is the best source of correct, engineering-based information.

8. Securely attach the upper hitch point with the proper-sized hitch pin and security clip.

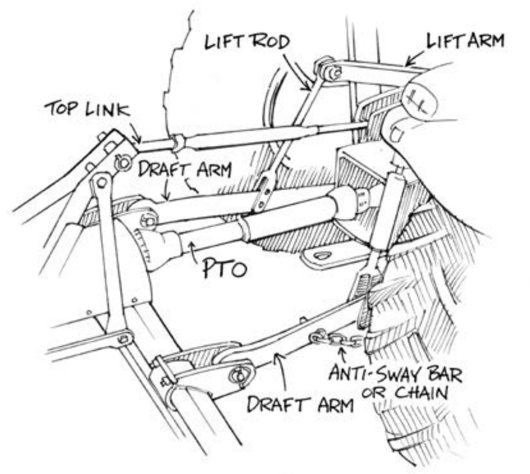


Figure 3.3 Parts of a 3-point hitch Credit: J. Mathison.

Figure 3.4 Never let another person stand between the tractor and the implement during hitching. Too fast of an approach or the operator's foot slipping from the clutch could lead to injury or fatality to the person standing nearby. Credit: J. Mathison.

Using Drawbar Implements

Several agricultural implements are ground-driven, which means the power comes from the wheels turning on the ground. Use of the PTO is unnecessary. With these implements, if forward movement stops, the machine stops operating. New tractor operators are often assigned to hitch to and use these types of drawbar implements.

A qualified operator should demonstrate how to safely use equipment before expecting a new driver to operate the equipment successfully.

This section focuses on towed equipment that is ground-driven.

Figure 3.5 Heavy-duty quick-attach couplers are mounted onto the tractor's 3-point hitch and can safely handle large 3-point hitch implements without a person moving between the tractor and the implement. Refer to the operator's manual for additional instructions on their use or have a qualified operator demonstrate to you the correct procedure to use a quick-attach coupler. Credit: J. Mathison.

Hitching Review

Follow these steps for drawbar hitching to an implement equipped with a height-positioning jack:

1. Back up to the correct position to align, or "spot," the hole in the drawbar with the hole in the tongue.
2. Stop the engine, put the tractor in park (if available), and set the brakes.
3. Dismount from the tractor to adjust the implement tongue height using the support jack.
4. Remount and start the tractor to make final adjustment to the "spot." If necessary stop the engine, put the tractor in park (if available), and set the brakes.
5. Attach the implement using the proper hitch pin and security clip, and move the jack to the transport position.

Figure 3.6 If the tongue of the implement is not adjusted for the height of the drawbar, the drawbar can push the implement to the rear, knock the jack stand over, or harm someone standing behind the implement. Taking a preliminary measurement of the drawbar height and the implement tongue before hitching makes aligning the two points much easier. A stable jack stand should be used. Credit: J. Mathison.

Hitching Safely

Backing up a tractor to connect an implement (figures 3.6 and 3.7) can be an easy and safe task. Practice backing up the tractor to align the drawbar with the implement hitch or tongue. Most drivers need no more than three changes of direction to do this job.

If the driver's foot slips from the clutch while hitching a machine, a helper could be crushed.

Figure 3.7 If you need help to hitch to a machine, insist that the helper stand off to the side of the operation. Many people have been crushed between tractors and machines trying to help connect the machine to the tractor. Never straddle the tongue of a piece of equipment when helping to hitch to a drawbar. You could be run over or crushed between the tractor and the implement. Credit: J. Mathison.

Using Ground-Driven Machinery

Disks, harrows, hay rakes, windrow inverters, and older manure spreaders are a few of the ground-driven implements (figure 3.8) assigned to beginning tractor operators. Use them safely by remembering these points:

1. Be aware of the width of the machine compared to the tractor.
2. Be sure the machine width is reduced to the "transport" position for travel on public roadways.
3. Shift the machine to the wider "field" position when ready to use it.
4. Stop the engine, securely park the tractor, and set the brakes before dismounting to engage the machine operation mechanism (levers, pins, etc.), allowing the wheels to turn the machine.

5. Pay attention to field boundary fences and obstacles before beginning field operations.

6. Allow plenty of space at ends of rows or fields to turn the equipment without "jack-knifing."

7. Be sure to return the implement to the transport position before using public roads or passing through narrow farm gates. Ground-driven implements operated on roadways can damage the road surface.

Figure 3.8 Implements can be wider than the tractor in transport or road position. Passing through farm gates or using public roadways can create a hazardous situation. Credit: J. Mathison

When using a particular implement for the first time, ask for a demonstration before trying the job.

Using 3-Point Hitch Implements

Once an implement is successfully connected to a tractor's 3-point hitch, the operator is ready to start using the machine. Some machines are powered by the PTO, while others are ground-driven (the power comes from the wheels turning on the ground). A qualified operator should demonstrate how to safely use equipment before expecting a new driver to use the machinery.

This section discusses 3-point hitch equipment that is both ground- and PTO-driven. Later sections will provide information regarding hydraulic connections and electrical connections between the tractor and the implement.

Hitching Review

Follow these steps for connecting implements to a 3-point hitch (figures 3.9 and 3.10).

1. Remove the drawbar, or move the drawbar forward or to the side for clearance.

2. Back the tractor so the pin holes of the tractor's draft arms are nearly aligned with the implement's lower hitch pins.

3. From the tractor seat and using the hydraulic lift controls, raise or lower the draft arms to match the implement's lower hitch pins.

4. Stop the engine, securely park the tractor, and set the brakes.

5. Attach each draft arm to the implement, and secure with the hitching pins and security clips.

6. Remount and restart the tractor, and then slowly raise the tractor's draft arms with the hydraulic lift controls to closely align the upper hitch points.

7. Stop the engine, securely park the tractor, and set the brakes.

8. Attach the tractor's upper hitching point of the 3-point hitch to the top hitch point of the implement with the proper-sized pin and securing clip. The upper link may need to be lengthened or shortened to fit. Ask for help or check the operator's manual if there is a problem.

Do as many hitching operations as possible with the engine shut off and the tractor securely parked.

Figure 3.9 On both the left and right sides of the implement, insert the draft arm attachment pin of the tractor into the pin holes of the implement's lower hitch assembly. Secure the hitch with the proper size hitch pins and security clips. Credit: J. Mathison.

Figure 3.10 After adjusting the upper link of the tractor's 3-point hitch to align with the upper hitch point of the implement, secure the equipment with the proper size hitch pin and security clip. The circled area indicates where the upper link may be adjusted for fit. The implement must be in a level position after the connection is made. Credit: J. Mathison.

The 3-point hitch works because the three hitch pins secure the implement to the tractor. Do not use chains or other temporary pins to attach the implement.

3-Point Hitches and PTOs

After connecting the implement to the tractor, power is needed to operate the machine if it is not ground-driven. A PTO driveline, hydraulic motors, and electrical devices are used. The PTO is the most common source of remote power. Three examples of PTO-driven implements a young agricultural worker may use or assist in using include rotary mowers (bush hogs), fertilizer spreaders (spin spreader), and post-hole diggers.

To attach the PTO shaft of a 3-point hitch implement, follow these steps:

1. Connect the 3-point hitch of the implement using the approved steps to align the hitch and to park the tractor securely.
2. Attach the implement driveline shaft to the PTO stub shaft of the tractor.

Here are some suggestions to make connecting the PTO easier:

- Align the implement PTO shaft splines with the splines of the stub shaft of the tractor. See the next section for more information.
- Press the detent lock (figures 3.11 and 3.12) inward as you slide the implement shaft onto the tractor PTO stub shaft.
- Slide the implement shaft forward far enough to make sure the detent lock has snapped into the lock position.

Figure 3.11 A firm grip will be needed to press in on the detent lock of the PTO shaft. This lock engages the groove in the stub shaft to secure the PTO driveline shaft to the stub shaft. There are also other forms of locking the PTO shaft. Credit: J. Mathison.

Figure 3.12 To attach the PTO shaft, you will be operating in a crowded space. Be sure the tractor is securely parked and the engine is shut off. Credit: J. Mathison.

Hitching Precautions for 3-Point Hitch Drawbars

Never pull a load with the 3-point hitch drawbar more than 13 to 17 inches above the ground or the pulling forces will be higher than the tractor's center of gravity. A rear overturn hazard may develop as the tractor moves forward.

Using the 3-Point Hitch Implement

Ground-driven 3-point hitch implements (figures 3.13 and 3.14) are often assigned to the beginning tractor operator.

- Do not make turns with a 3-point hitch implement in or on the ground. This places undue force on the 3-point hitch draft and lift arms, which can damage the machine.
- Backing up a 3-point hitch implement, such as a small planter, while it is lowered onto the ground can plug the seed drops of the planter. Lift the implement before reversing direction to prevent possible damage to the implement or 3-point hitch draft and lift arms.

Figure 3.13 If the 3-point hitch is equipped with an extension to the lower draft arm, release the lock and pull or extend the draft arm extension to the rear before nearing the implement to be attached. Credit: J. Mathison.

Lift the 3-point hitch implement from contact with the ground before turning, backing, or transporting.

Figure 3.14 The telescopic extension to the draft arm is fully extended. In some cases, this must be done to align with the lower lift points of the 3-point hitch implement. Be sure the extension is pushed back into the draft arm until locked into place when you are finished attaching the implement. Credit: J. Mathison.

Making PTO Connections

The power takeoff (PTO) shaft, or implement input driveline (IID), is an efficient means of transferring mechanical power between farm tractors and implements. This power transfer system helped to revolutionize North American agriculture during the 1930s. The PTO is also one of the oldest and most persistent hazards associated with farm machinery.

PTO Components

Figure 3.15 shows the components of an implement PTO system. Two typical PTO system arrangements are shown. The top drawing is of a PTO system with a pedestal connection found on many types of towed implements (hay balers, forage choppers, large rotary mowers, etc.). The lower drawing is of a PTO system in which the implement's input driveline connects directly to the tractor PTO stub. Examples of this type of connection include three-point hitch-mounted equipment, such as post-hole diggers, small rotary mowers, fertilizer spreaders, and augers.

Connections from the tractor to the implement are made through the flexible universal joints. The "U-joints" are connected by a square rigid shaft that turns inside another shaft. The PTO shaft can telescope in and out for use in turns or over uneven terrain.

The combination of universal joints and turning shafts provides the remote power source to a farm implement. Proper guarding is necessary to protect the operator's safety.

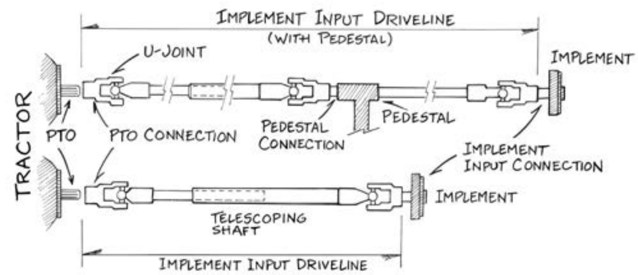


Figure 3.15 The major components of a PTO system. Two types of PTO systems are shown. Credit: J. Mathison.

The PTO is one of the oldest and most persistent hazards associated with farm machinery.

PTO Connections

After spotting the hitch to connect the tractor to the implement, the operator must attach the PTO shaft of the tractor to the implement by way of the implement input driveline (IID) (see next section). These connecting shafts can be heavy, greasy, and difficult to manipulate in the cramped space between the tractor and the equipment. The youthful operator must have a strong grip and will often have to work at an awkward angle. *Check the table of Ag Youth Work Guidelines from Cultivate Safely in the introduction or the Cultivate Safely website (**cultivatesafety.org/work/**) to determine who can handle the task of PTO connection.*

This section discusses PTO design and how to make PTO connections by using knowledge of their design.

PTO Stub Shaft Design

PTO Speeds—Tractor PTOs are designed to rotate at 540 rpm or 1,000 rpm (figures 3.16 to 3.18). Shiftable, dual-speed PTOs may reach a maximum design speed of 630 rpm or 1,170 rpm.

PTO Splines—By counting the number of splines, or teeth, on a PTO stub shaft, the beginning operator can identify the speed of the PTO shaft in rpm. A 540-rpm PTO shaft will have six splines or teeth. A 1,000-rpm PTO shaft may have 20 or 21 splines or teeth. The faster the PTO speed, the more teeth are used to make the PTO connection between the tractor and the implement.

PTO Sizes—PTO stub shaft diameter for a 540-rpm shaft is 1 ⅜ inch. The 1,000-rpm stub shaft with 21 splines or teeth is 1 ⅜ inch. The 1,000-rpm stub shaft with 20 splines or teeth has a diameter of 1 ¾ inch.

540-rpm PTOs have six splines or teeth. 1,000-rpm PTOs have 20 or 21 splines or teeth.

PTOs must be guarded to prevent an entanglement hazard.

Figure 3.16 The 540-rpm PTO stub shaft has 6 splines or teeth and is 1 3/8th inch in diameter. Credit: J. Mathison.

Figure 3.17 The 1,000-rpm PTO stub shaft has 20 splines or teeth with a 1 ¾-inch diameter. It could instead have 21 splines with a 1 ⅜-inch diameter. Credit: J. Mathison.

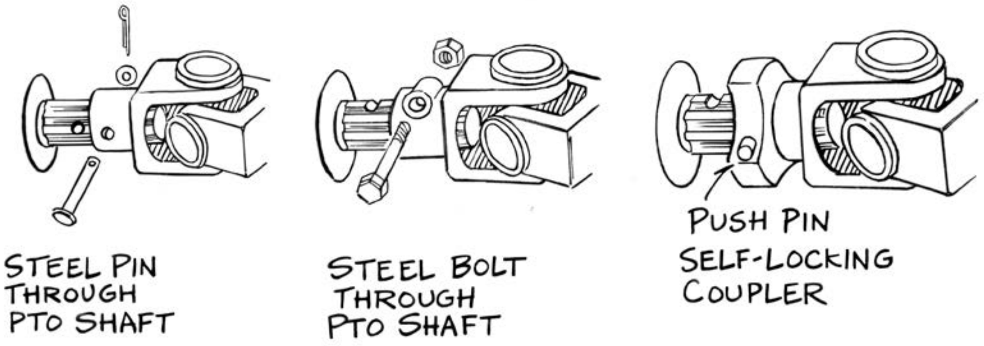


Figure 3.18 Various means to secure the PTO shaft to the stub shaft have been used over the years. Besides the connection methods shown here (older on left, newer on right) another common style is the push pin detent locking type shown in figure 3-11. All types of locking device areas must be guarded because they are wrap points where the operator can become entangled in the PTO. Credit: J. Mathison.

Connecting the PTO

Follow these steps to attach the PTO shaft of a 3-point hitch implement:

1. Connect the tractor to the drawbar or to the 3-point hitch of the implement using the approved steps described earlier in this chapter (page 148).

2. Attach the PTO shaft of the implement to the PTO stub shaft of the tractor.

Here are some suggestions to make the PTO connection easier:

- Align the driveline PTO shaft splines with the splines of the stub shaft of the tractor. If the splines will not align, try turning the tractor PTO stub shaft slightly, or use the implement flywheel to move the implement's PTO shaft. Get a demonstration of this procedure, if necessary.
- Press the detent lock push pin inward and slide the implement shaft onto the tractor stub shaft.
- Slide the implement shaft forward far enough to make sure the detent pin has snapped into the lock position.

PTO Care and Use

Dirt and grease can make the PTO shaft difficult to grasp and connect. Keep the PTO shaft off the ground. Wipe the excess grease from the PTO shaft with a cloth.

Important: A new PTO shaft has paint inside the splines. This may prevent the shaft from fitting over the PTO stub. The paint must be removed.

PTO Phasing

Older PTO shafts can be separated or pulled apart. The two parts are made so one part fits into the other. The PTO must be able to telescope in and out to permit machine operation over irregular terrain. If the parts become separated, they must be reassembled "in phase" (figure 3.19) to avoid placing extra strain on the universal joints. Many shafts are designed to prevent this from happening.

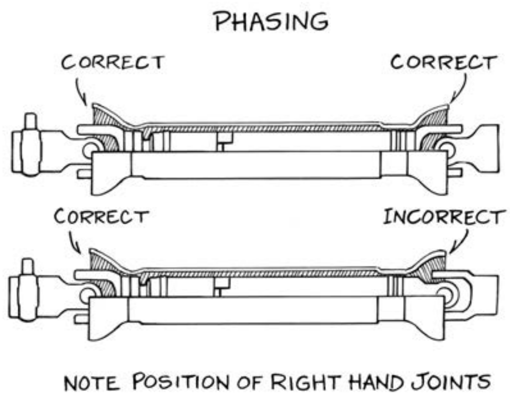


Figure 3.19 The upper portion of the drawing illustrates a correctly phased universal joint. You may wish to check the phasing on a PTO shaft. Credit: J. Mathison.

Ag Youth Work Guidelines for PTO Use

The cultivate safety recommendations for connecting and disconnecting a PTO shaft are shown below. These recommendations were developed by a knowledgeable group of safety experts to help parents and other supervisors match youthful agricultural workers with the tasks appropriate to their development.

Adult responsibilities:

- Be sure implement is in working order.
- Be sure all safety features are in place.
- Be sure the work area has no hazards.
- Be sure the youth ties long hair back or up out of the way, and wears nonskid shoes and snug-fitting clothes. Hearing protection is recommended as well.

The adult in charge should also evaluate the youth by asking the following questions (figure 3.20):

1. Can the youth drive the tractor skillfully?
2. Can the youth hitch and unhitch implements?

3. Does the PTO shaft weigh more than 10%–15% of the youth's body weight? To avoid back injury, this should be the maximum weight they should lift.
4. Can the youth follow a five-step process?
5. Has the youth been trained in proper lifting techniques?
6. Has an adult demonstrated connecting and disconnecting a PTO?
7. Can the youth do the job four or five times under direct supervision?
8. Can an adult provide the recommended supervision?

Figure 3.20 This is what the task of connecting a PTO shaft looks like. You must lift a heavy object at an awkward angle while squeezing in the lock mechanism detent pin. Watch someone else connect a PTO several times before doing this job. Credit: J. Mathison.

A youth's experience level may be acceptable to him or her, but proof of their expertise should be evaluated by a qualified tractor operator.

Connecting a PTO shaft will be easier after practicing the job several times.

PTO Entanglement

A study published in 2007 analyzed 151 incidents in the United States involving farm PTO and similar injuries to youth under age 18. These incidents often resulted in severe injuries, including amputations, spinal cord injuries, and compound bone fractures. Youth, primarily males, age 13, had the highest frequency of incidents. More than half of all cases involved youth ages 12–17. Autumn was the most common season for injury. Nearly half of all cases involved amputations. Augers, elevators, and conveyors most frequently caused injuries.

PTO Safety Practices

There are several ways to reduce the risk of PTO injuries and fatalities. These safety practices offer protection from the most common types of PTO entanglements (figures 3.21, 3.22, and 3.23):

- Keep all components of PTO systems shielded and guarded.
- Regularly test driveline guards by spinning or rotating them to ensure they have not become stuck to the shaft.
- Disengage the PTO and shut off the tractor before dismounting to clean, repair, service, or adjust machinery.
- Walk around tractors and machinery rather than stepping over a rotating shaft.
- Always use the driveline recommended for each machine. Never switch drivelines among different machines.
- Position the tractor's drawbar properly for each implement used. This will help prevent driveline stress and separation on uneven terrain and in tight turns. (See the beginning of this chapter for more information.)
- Reduce PTO shaft abuse:

  Avoid tight turns that pinch rotating shafts between the tractor and machine.

  Keep excessive telescoping to a minimum.

  Engage power to the shaft gradually.

  Avoid over-tightening slip clutches on PTO-driven machines.

If PTO guards are removed or damaged, they should be replaced immediately.

Figure 3.21 This PTO stub shaft is protected with a tractor master shield and stub shaft cover. To remove the stub shaft cover, grip the cover firmly and turn counterclockwise. Store the stub shaft cover where it will be available to replace when the job is done. Credit: J. Mathison.

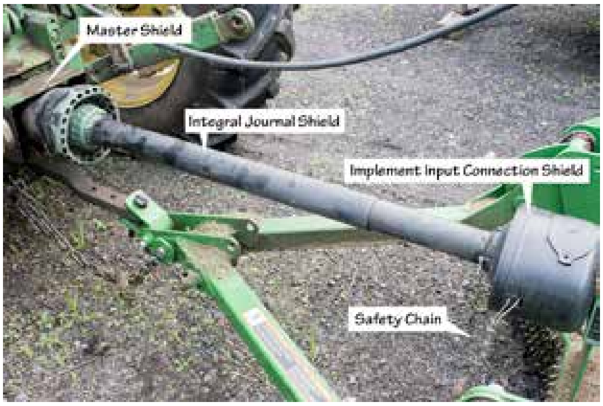


Figure 3.22 The major guards of a PTO system. The implement input connection (IIC) shield protects the operator from the IIC, including the implement input stub and the connection to the implement input driveline (IID). The safety chain keeps the integral journal shield from spinning and shows that the shield is not stuck to the IID. The safety chain should be replaced immediately if damaged or broken. The master shield protects the operator from the PTO stub and the connection of the IID to the PTO stub. The integral journal shield completely encloses the IID, may be made of plastic or metal, and is mounted on bearings to allow it to spin freely from the IID. The integral journal shield should always be checked before operation for free movement. Credit: J. Mathison.

Figure 3.23 PTO shielding can be missing, bent, or inadequate. Notice that the guard for the implement drive shaft is missing, the tractor master shield is bent, and the tractor master shield does not provide protection for the driveshaft U joint. Youth should not operate PTO-powered machines that are not properly guarded. Credit: J. Mathison.

Implements with Hydraulic Components

Many implements are powered by a PTO shaft, but others are powered by hydraulics (or fluids), electrical connections, or some combination of these. This section explains how to properly care for and use the hydraulic systems located on the tractor and used with the implement.

Hydraulic Power

The term "hydraulic" refers to fluids under pressure. Any liquid can be placed under pressure, but not all liquids are used for hydraulic work. An undrained garden hose left lying in the sun provides an example. When the nozzle is turned on, solar-heated water erupts from the hose with great force. Water, however, becomes steam at 212 degrees Fahrenheit and could not be used as a working hydraulic fluid.

Oil is the common hydraulic fluid used with farm equipment. Hydraulic oil system components are shown in figure 3.24.

Hydraulic fluids work through systems with very small openings and are under great pressure. Users must observe several precautions.

Wear safety glasses or a face shield and gloves when checking hydraulic systems.

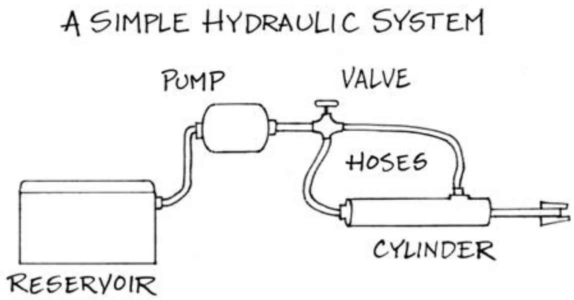


Figure 3.24 Hydraulic systems are closed systems that move and control fluid (hydraulic oil) for the purpose of operating cylinders and/or motors. This drawing gives a general look at hydraulic components. Much more detail is involved in these systems than this drawing shows. Filters, pressure relief valves, accumulators, etc., are included as well. Consult a machinery owner's manual to see drawings of more complex hydraulic systems. Credit: J. Mathison.

Precautions When Using Hydraulics

To operate hydraulic systems safely and correctly, understand these three points:

- need for clean oil
- heat generated by use
- oil leaks under pressure

If necessary, discuss these points with a knowledgeable farmer or mechanic.

Clean Oil

Hydraulic pumps and control valves operate with minute clearances (tolerances). Grit, grime, and dirt pushed through these openings (figure 3.25) can eventually wear the surfaces and damage the system. Clean hydraulic oil must be used. The fill area and connections must be kept clean as well. Dirt is the greatest source of hydraulic system damage.

Figure 3.25 Missing hydraulic connection covers signify a problem with this tractor. What will happen to the hydraulic system if the dust covers are not kept in place? Credit: J. Mathison.

Hydraulic connector covers should be in place to keep out dust, dirt, grease, and moisture. Clean connections keep systems working longer.

Hydraulic system pressure may exceed 2,000 pounds per square inch (psi). Pin-hole size leaks can develop.

Heat Generated by Use Hazards

As hydraulic fluid moves through the closed system, the fluid meets resistance from the load to be lifted or moved. Pressure increases and heat builds from friction. Under extreme load conditions, the reinforced hoses can become hot, but metal connections, fittings, and piping can become super-heated (figure 3.26). *Place your hand near the connection to sense for heat before touching the connection*. If hot, allow the hydraulic system to cool down before touching the heated connections.

Figure 3.26 Hydraulic hoses and fittings can become hot during use. Place your hand near them to check for heating. Do not just grab them! Credit: Association of Equipment Manufacturers.

High-Pressure Oil Leaks

Pressure within the hydraulic system can exceed 2,000 psi. Reinforced hoses develop pinhole leaks (figure 3.27) and hydraulic connections can vibrate loose.

Hydraulic leaks may be hard to see. **Never check for these leaks with your hand** (figure 3.28). The high pressure can inject oil droplets under your skin. Oil injected under your skin is a medical emergency requiring immediate medical care. Gangrene can occur, and limb amputation may be necessary.

Figure 3.27 Hydraulic hoses may be reinforced, but damage to the outer covering, plus pinholes from high pressure, can cause serious injury (e.g., amputation) and machinery downtime. Credit: J. Mathison.

Figure 3.28 Use a magnifying glass, mirror, or piece of cardboard to check for high-pressure hydraulic leaks. Do not use your hand! Pinhole leaks are often invisible. Credit: J. Mathison.

Fittings and Connections

Connecting Hydraulic Hoses to Couplers

Hydraulic couplers (figures 3.29 and 3.30) make the connections quick and simple to use. Follow these steps:

1. Use gloves or a wipe cloth to remove dirt and grit from the couplers.
2. Remove the dust covers from the couplers.
3. Push the couplers together until the lock ring snaps the two parts securely (figure 3.31). Older-style lock levers and manual pull lock rings may also be found. Ask for a demonstration of these.

If making the connection is difficult, try the following:

- While seated on the tractor where no hydr aulic lift arms or other moving parts can cause injury, move the hydraulic control levers back and forth to release the static pressure. The previous operator may have failed to do this.
- Move the locking ring of the female coupler back and forth to be sure dirt has not blocked its movement.

In some circumstances, the hoses leading to the hydraulic cylinders may have become reversed. The system will still operate. However, using the system with hoses reversed will cause the control valves/levers to have the opposite action expected. This can lead to hazardous situations in which operators must react quickly and adjust their knowledge and skills to the new condition. To correct the reversal problem, disconnect the hydraulic hoses and switch them to the opposite female coupler.

If hydraulic repairs have changed the standard coupling setup, ask for help or check the operator's manual to determine which hose goes with which coupler.

Figure 3.29 The female half of the hydraulic coupler is considered to be part of the tractor. Dust covers protect the quick release fitting, which includes the lock ring and ball lock mechanism. Credit: J. Mathison.

Figure 3.30 The male half of the coupler is part of the cylinder or hydraulic device system. Be sure to wipe dirt and grime from the hose end fitting. Credit: J. Mathison.

Figure 3.31 The lock ring of the female end of the coupling will secure the two fittings together. A firm grip is needed to insert the hydraulic hoses from the implement (male end) into the coupling on the tractor (female end). Credit: J. Mathison.

Hydraulic systems in operation can produce pressure in excess of 2,000 psi. Oil trapped in a hydraulic component may still be under enough pressure to cause mechanical problems or hazards. Someone's faulty repairs may have created several problems the beginning operator cannot solve.

Disconnecting Hydraulic Hoses

To disconnect hydraulic hoses:

- Relieve the static pressure by moving the hydraulic control levers back and forth.
- Push back on the lock ring.
- Remove the hydraulic hose.
- Replace the dust caps on each connector.
- Hang the hoses on the implement.
- Keep hoses off the ground.

Implements with Electrical Connections

This section explains how to properly care for and use the electrical systems located on the tractor and used with the implement.

Electrical Needs

Modern farm implements come equipped with many features that need electrical power (figure 3.32).

Lights—Added to implements to allow nighttime field operation, provide lighting for nighttime repair work, and serve as warning signals during public roadway transport.

Electrical sensors—Used to measure equipment operation functions and can stop the implement if problems arise (figure 3.33).

Monitors—Signal the operator when a machine function is disrupted. For example, corn planter monitors can signal the tractor operator to discontinue the planting operation if, for example, the planter is not dropping seeds because of a plugged seed drop tube.

Warning devices—Can be activated when using the reverse gear, which sounds an alarm while backing the tractor and implement. Horns and flashing lights also serve to warn bystanders.

Convenience outlets—Using a wiring harness, permit connection to a trailer or wagon for proper lighting for public road use.

Modern tractors and equipment rely not only on PTO and hydraulic systems, but on electrical accessories to complete the work package.

Figure 3.32 Some connected implements need electrical power. Connectors may have prongs with screw-in couplings to keep them from vibrating loose. Other connectors may be plug types that are simply pushed together (shown here). Recognize the difference to avoid damage when connecting or disconnecting them. Credit: J. Mathison.

Figure 3.33 Electrical connectors are protected from dust, dirt, grease, and grime with dust caps. Keep these covers in good repair and in place to ensure that electrical connections can be made without delay. Credit: J. Mathison.

Electrical connector covers should be in place to keep out dust, dirt, grease, and moisture. Clean connections keep systems working without delays.

Using Electrical Connections

Follow these instructions to properly care for and use electrical connections:

- Turn the powered device to the "off" position before connecting or disconnecting the electrical apparatus. Power surges can damage electronic components.
- Wipe away moisture and dirt before making the connections.
- Carefully lift the protective cover to make the connections. Protective caps can be broken and the electrical contacts exposed to moisture, dust, and dirt.
- Slowly and carefully align the prongs or plugs of the connectors. Do not force connections together, which can cause damage.
- Grip the connector body (figure 3.34) when disconnecting the circuit. *Do not pull on the wires*. Grasp the connectors firmly, and separate them using a straight-line pull. Expect some connections to be tighter than others. A threaded connector must be unscrewed first. Others require a half-turn before disconnecting them.
- Consult the operator's manual for other precautions in using electrical components.

Be sure the electrical cables cannot be caught or pinched by hydraulic lift arms or moving parts of the equipment.

To see another set of suggested rural roadway safety activities, visit **progressiveag.org**.

Figure 3.34 Align the pins of the electrical connection before attaching. Do not force the connector if the pins are not aligned. Threaded connectors do not pull loose; unscrew them first. Credit: J. Mathison.

ACTIVITY 3.1

Hitching Implements to Drawbars and 3-Point Hitches

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Safely connects an implement to a tractor's drawbar and to a tractor's 3-point hitch.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–2 and can fasten an implement to a tractor's drawbar and 3-point hitch.

Life Skills: Comprehension, spatial skills, advanced tractor operation, hitching, implement safety

Tags: Advanced tractor operation, hitching, implements

Time Needed: 1 hour or more, depending on the experience of students and the number of tractors and instructors available

Materials List:

- copy of Let's Do It
- tractors, preferably medium sized (~35-50 HP), with wide front-end wheels, an ROPS, and a seat belt
- at least one farm implement attached via a drawbar (with operator's manual for implement)
- at least one farm implement attached via a 3-point hitch (with operator's manual for implement)

Space: Farmyard or field

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before You Begin: Point out the tractor's safety features when you start the activity.

Introduction: Review the Hitching and the Center of Gravity, 3-Point Hitch, and Using Drawbar Implements sections of Chapter 3.

See also *National Safe Tractor and Machinery Operation Program, Student Manual*, 2nd ed. 2013. Penn State, Ohio State University Extension, and National Safety Council. Task Sheet 5.1. Connecting Implements to the Tractor.

Opening Questions: Have you ever seen someone effortlessly hitch a tractor to an implement? An experienced operator makes it look easy, but if you've ever attempted this task, you know it takes a lot of practice. Let's give hitching a try!

LET'S DO IT!

ACTIVITY 3.1

Hitching Implements to Drawbars and 3-Point Hitches

1. Practice backing up a tractor with a drawbar to an implement to "spot" (align) the hole in the drawbar to the hole in the implement tongue. You should be able to perform this skill with a minimum number of changes of direction.

2. Practice backing a tractor with a 3-point hitch to an implement to adjust the pin hole in the draft arms to the lower hitch pins on the implement's 3-point hitch attachment. As you become more able to align these points, securely park the tractor. Attach the draft arm hitch pins, restart the tractor, adjust the draft arms to align, and connect the upper link point. You should be able to perform this skill with a minimum number of changes of direction.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 3.2

Making PTO Connections

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to identify the components of a PTO system and the hazards associated with its use, attach the PTO driveline between the tractor and the implement, and work safely when using a PTO.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–5, can identify the components of a PTO system and the hazards associated with PTO use, and can attach the PTO driveline between the tractor and the implement. Youth demonstrates safe habits when using a PTO.

Life Skills: Comprehension, math, advanced tractor operation, hitching, implement safety, PTO safety

Tags: Advanced tractor operation, hitching, implements, PTO use

Time Needed: 1 hour or more, depending on the experience of students and the number of tractors and instructors available

Materials List:

- at least two tractors, preferably medium sized (~35-50 HP), with wide front-end wheels, an ROPS, and a seat belt
- at least two PTO-powered implements
- pens, pencils, paper
- copies of Let's Do It!
- calculators (optional)

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange for at least two tractors and two types of implements to be available at a location where youth can observe different sized PTO shafts.

Introduction: Review the 3-Point Hitches and PTOs, Making PTO Connections, PTO Care and Use, and PTO Entanglement sections of Chapter 3.

Opening Questions: Are you familiar with any PTO-powered implements used on the farm? Can you name other PTO-powered farm implements? Do you know anyone who's had an incident with a PTO? If so, discuss with the group what happened.

ACTIVITY 3.2

Making PTO Connections

1. Fill in the blanks:

   A. A PTO shaft with 6 teeth on the shaft is designed for _____ rpm of speed.

   B. A PTO shaft that has 20 teeth on the shaft is designed for _____ rpm of speed.

   C. A PTO shaft that has 21 teeth on the shaft is designed for _____ rpm of speed.

   D. What is the maximum percentage of body weight that a 14– or 15-year-old worker should be expected to lift without straining the back muscles?

   ______________ % of their body weight.

   Calculate this percentage for you. __________ lbs.

2. Suppose you are working with another tractor operator. They are sitting on the tractor seat and are able to reach the PTO control. If your shoelace is caught in the PTO shaft, how long does the shoelace need to be in order for the tractor operator to have enough time to shut off the PTO before your foot is pulled into the PTO shaft? The PTO shaft is spinning at 540 rpm, the shaft diameter (d) is 3 inches, and the operator can react by shutting off the PTO in 3 seconds. Follow these steps to answer this question.

   A. Find the circumference of the PTO shaft.

   Circumference = π d = 3.14 x 3 inches = _______ inches

   B. How many times does the PTO shaft rotating 540 revolutions per minute rotate in one second?

$$\frac{540 \text{ revolutions}}{1 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} = \frac{540 \text{ revolutions}}{60 \text{ sec}} = \underline{\hspace{3cm}} \frac{\text{revolutions}}{\text{sec}}$$

C. How many times does the PTO shaft rotate in 3 seconds?

Answer b x 3 sec = ________ revolutions

D. How much shoelace will become wrapped up in the PTO in 3 seconds?

Answer a (in inches) x *Answer c* (in revolutions) = _____ inches of shoelace.

What does your answer tell you to do to ensure safety around PTOs?

____

3. Conduct a survey of the tractors on a farm (or those provided) to determine how many have 540-rpm PTO shafts and how many have 1,000-rpm PTO shafts. Record the results.
4. Check the phasing of two or three PTO shafts. Make a drawing of the universal joints on each end of the PTO shaft. Did you find any PTO shafts that were out of phase? If so, label the drawing to show what was wrong. Tell your supervisor.
5. Practice lifting a PTO shaft with your right hand and operating the locking mechanism of the PTO shaft connector. Practice the same thing using your left hand. From which side were you able to accomplish this best?

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 3.3

Implements with Hydraulic and/or Electrical Components

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to connect hydraulic and electrical components of towed farm implements safely and correctly.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–9 and can safely and correctly connect hydraulic and electrical components of towed farm implements.

Life Skills: Comprehension, advanced tractor operation, hitching, implement safety, hydraulic systems, electrical systems

Tags: Advanced tractor operation, hitching, implements, hydraulic, electrical

Time Needed: 1 or more, depending on the experience of students and the number of tractors and instructors available

Materials List:

- at least two tractors, preferably medium sized (~35–50 HP), with wide front-end wheels, an ROPS, and a seat belt
- at least two different farm implements with electrical and hydraulic components (with operator's manuals)
- copies of Let's Do It!
- pens, pencils, paper

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Note: NAGCAT recommends that 14- and 15-year-old youth operate front-end loaders on tractors of less than 20 horsepower only. Proper training is required to operate a front-end loader on a larger tractor.

Introduction: Review the Implements with Hydraulic Components and the Implements with Electrical Connections sections of Chapter 3.

Opening Questions: What are some farm implements that use hydraulics? Name some that need electrical power. Name some that use both hydraulics and electrical power. What are some jobs that these implements are used for? Have you used any of these implements?

LET'S DO IT!

ACTIVITY 3.3

Implements with Hydraulic and/or Electrical Components

1. Answer these questions by circling the correct response:
   A. What is the greatest source of damage to a hydraulic system?

      Water Dirt Air None of these

   B. The term hydraulic refers to:

      Fluid under pressure Air under pressure Gas under pressure

   C. Hydraulic pressures on farm equipment may exceed _____________ psi

      500 psi, 2,000 psi 10,000 psi

   D. The safe way to check for pinhole leaks in the hydraulic system is to:
      1. Rub your hand over the hose.
      2. Hold a match near where you suspect the leak.
      3. Hold a piece of metal or cardboard near where you suspect the leak.
2. On two different tractors, identify all the hydraulic system components that are external to the tractor. Name the parts and explain their purpose to a partner or mentor.
3. Check the hydraulic fluid level of two tractors.
4. Practice connecting the hydraulic hoses to the tractor coupler.
5. Examine several tractors and implements to learn the positions of electrical connections and control switches or knobs that activate the circuits they connect.

6. Review the operator's manual of at least one farm implement to learn more about machinery monitors, crop sensors, and remote lighting features.
7. Practice connecting electrical wiring harnesses together to get the feel of how easily the connection can be made.
8. Ask a qualified tractor operator to demonstrate a tractor's electrical components for you.
9. With supervision, practice using the tractor hydraulic system:
    - Raise and lower the 3-point hitch arms.
    - Raise and lower a front-end loader bucket.
    - Tilt a front-end loader bucket.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 3.4

Driving a Tractor with an Implement

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Safely drives a tractor forward and backward with implement in tow.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–2, and can safely drive a tractor forward and backward with implement in tow.

Life Skills: Comprehension, advanced tractor operation, driving, steering, hitching, implement safety

Tags: Advanced tractor operation, driving, steering, hitching, implements

Time Needed: 1 hour or more, depending on the experience of students and the number of tractors and instructors available

Materials List:

- tractors, preferably medium sized (~35–50 HP), with wide front-end wheels, an ROPS, and a seat belt
- at least one two-wheeled, drawbar-attached implement
- cones or other markers for tractor driving course
- copies of Let's Do It

Space: Open, flat field or farm lane

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Scout out an open, flat area for tractor driving practice. Also, plan out a challenging course for the youth to try once they've gained experience in the open, flat area. See **paffa.org/page.aspx?ID=406** for the Pennsylvania FFA tractor/equipment driving course and information. Alternatively, you may refer to the National Safe Tractor and Machinery Operation Program (NSTMOP) tractor skills and driving test layout map in Activity 2.10 Practice Driving a Tractor.

Note: All tasks are to be done under the supervision of an experienced operator.

Introduction: Review the Hitching and the Center of Gravity and Using Drawbar Implements sections of Chapter 3.

Opening Questions: Have you ever seen someone effortlessly maneuver a tractor with a hitched implement around obstacles and corners? How about backing a tractor hitched to an implement into a tight space? An experienced operator makes it look easy, but if you've ever attempted these tasks, you know it takes a lot of practice.

LET'S DO IT!

ACTIVITY 3.4

Driving a Tractor with an Implement

1. Practice driving a tractor with a drawbar-attached implement. First, go in a straight line forward, then turn while going forward, then try backing in a straight line, and finally try backing around curves. As you develop skill, make the turns tighter.
2. Practice moving the tractor with a drawbar-attached implement uphill and downhill from a standing start.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Chapter 4
Materials Handling Equipment

Please see the Note to Leaders at the front of this book for some important safety and logistics considerations.

Skid Steers

Skid steer loaders are versatile machines. They fit into small spaces, can turn within a tight radius, and are easy to operate. Young farmworkers enjoy work success with the skid steer loader.

This section discusses the safe use of skid steer loaders. They are safe to use if the operator works within the machine's limitations. As in all machinery use, the operator must know the machine's proper uses, as well as its limitations.

Skid Steer Loader Basics

Hydraulic Power

A skid steer loader is a hydraulic workhorse. A hydrostatic transmission controls forward and reverse direction. Hydrostatic valves control the flow of hydraulic oil to steer the machine by "skidding" it sharply around corners. Hydraulic cylinders raise and lower lift arms and tilt the load bucket. See the earlier section, "Implements with Hydraulic Components," for a review of hydraulic power.

Hydraulic power is positive power. The machine moves the instant the hydraulic control levers or pedals are moved. The skid steer will move forward, reverse, or turn sharply around corners. The load bucket will lift, roll, or tilt. **Bumping the control levers can cause the machine to move unintentionally.**

Weight and Stability

A skid steer can move heavy loads. An operator of a skid steer may attempt to lift or move more weight than the skid steer is designed to handle. The skid steer's center of gravity is low and between the wheels. A load carried too high raises the center of gravity and increases the risk of a side or rear overturn. See the sections Tractor Stability and Using the Tractor Safely as a review of center of gravity.

Machine Hazards

Skid steer loaders (figure 4.1) function to push, scrape, scoop, lift, and dump materials. Lift arms raise and lower a load bucket near the operator's cab. The load bucket is mounted in front of the operator and can be rolled forward or tilted back within inches of the operator.

Control levers, pedals (figure 4.2), and a parking brake are arranged compactly within the operator's space. Operators must use caution to avoid bumping these controls. Workers have been crushed between lift arms and the skid steer. Load buckets have dropped onto workers and killed them. Load buckets have rolled back and crushed a worker's legs.

Pinch points, shear points, and crush points exist within close reach of the operator's space. See the Mechanical Hazards section in Chapter 1 to review pinch point, shear point, and crush point hazards.

Figure 4.1 A skid steer loader. Credit: Pixabay CC0.

More than half of skid loader fatalities are due to crushing by lift arms and load buckets.

Operating the Skid Steer Loader

Preventive Maintenance

Before using the skid steer, complete a pre-operation inspection of the machine. Check the oil level, tire pressure, coolant level, and fuel. See Preventive Maintenance and Pre-Operation Checks in Chapter 2 to review similar items to check on a tractor.

Entering and Exiting the Skid Steer

Before entering the machine, observe the following points:

- The lift arms and bucket should be completely lowered. Do not reach into the cab from the ground level to move hydraulic levers or pedals to position the lift arms and bucket. Crushing can result.
- The seat and floor should be clear of obstructions. Objects can roll beneath foot control pedals and interfere with the machine's operation.

To enter the skid steer, use the grab bars (hand holds) and the tread plates mounted on the load bucket. A three-point hold provides the safest footing. The load bucket and machine surfaces can be slippery when wet or muddy. Exit the machine in the same manner. When seated, lower the restraint bar and/or fasten the seat belt immediately.

Controls

Before using the skid steer, become familiar with the controls. A qualified person should demonstrate how to start and stop the engine; how to move the machine forward and backward; how to steer the skid steer; and how to raise, lower, and tilt the bucket attachment. Learn how to safely change attachments. If an attachment to the skid steer uses hydraulic power, ask for a demonstration of how to engage the remote hydraulic unit.

The beginning operator should understand the following points:

- **Movement controls**—Grasp the right and left hand control levers; push both levers forward to move forward, or pull the levers rearward to move in reverse. Let go of the levers to stop the movement.
- **Steering controls**—To control the steering direction, push one hand lever forward while pulling the other lever back. Pushing the left lever forward while pulling the right lever back makes the skid steer travel to the right.

- **Lift controls**—Foot pedals control the lift arms and load bucket. The left pedal raises and lowers the lift arms, while the right foot pedal tilts the bucket to dump or rolls the bucket back. See figure 4.2. for more details. These movements must be done smoothly. Hard-soled shoes give better feel for the pressure needed on the pedal. Some models use the hand controls to make these movements.

Joystick controls are also used to control the functions of the skid steer. Get advice on their use from a knowledgeable operator.

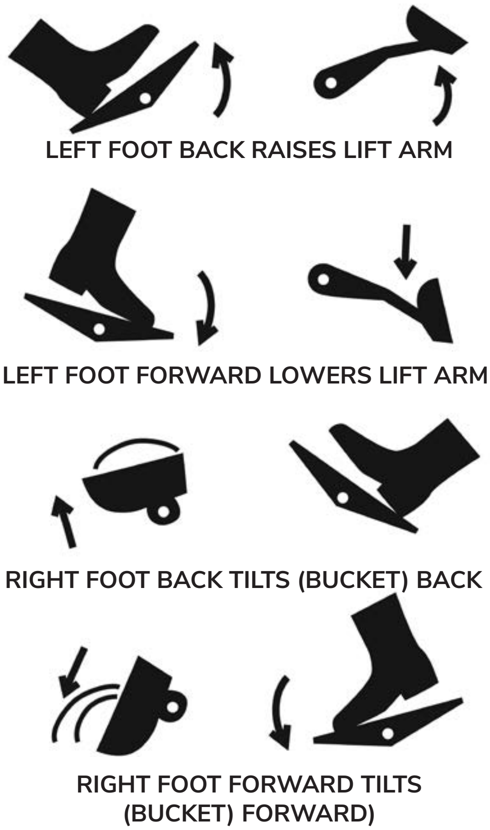


Figure 4.2 The operator's hands and feet control the skid steer. Foot controls raise the lift arms (boom) and tilt or roll the bucket. The left heel raises the lift arms. The left toes lower the lift arm. The right heel rolls the bucket back to load. The right toes tilt the bucket to dump the contents of the bucket. Practice these actions before proceeding to operate the skid steer. Credit: J. Mathison.

Use both hands and both feet to control the skid steer's work.

Skid Steer Safety

Skid steer loaders can work in small areas, but they have limitations similar to tractors. Follow these skid steer safety recommendations:

- One seat and one seat belt mean one operator. No passengers are permitted on the bucket.
- Operators must lower the safety restraint bar and/or fasten the seat belt every time they enter the machine.
- Be sure the area around the skid steer is clear of children, bystanders, animals, and unnecessary equipment.
- Do not work near overhead utility lines.
- Lower the load bucket for travel.
- Use slower speeds over rough ground.
- Do not overload the bucket. Skid steers have a Rated Operating Capacity. Exceeding capacity with a lifted load will result in forward or sideways tipping of the machine (figure 4.3).
- When moving up a slope, keep the heaviest weight up the hill. With an empty bucket, back up the hill. With a full bucket, drive forward up the hill (figure 4.4).
- Avoid crossing steep slopes.
- Avoid ditches, stream banks, and silage pile edges to prevent turnovers.
- Lower the boom and bucket, stop the engine, and set the parking brake before dismounting the machine. **Do this every time.**
- Be aware of the danger of lift arms or load bucket movements and never lean or stand in their way.
- Use the lift arm locks (boom locks) to prevent lift arms from dropping downward if repairs must be made to the machine.

- Prevent load rollback by securing loads in the bucket and filling the bucket only to rated levels.
- Do not reach outside of the cab while the skid loader is running. All adjustments and connections of attachments should be made with the engine stopped.

Safe skid steer loader work requires attention to the machine, the surroundings, and the work being done.

Figure 4.3 Skid steer loaders can tip forward if overloaded. This is an important reason to wear your seat belt and to understand the skid loader's load limitations. Credit: J. Mathison.

Some skid steer models use joystick-type controls to raise and lower the lift arms and to tilt the load bucket.

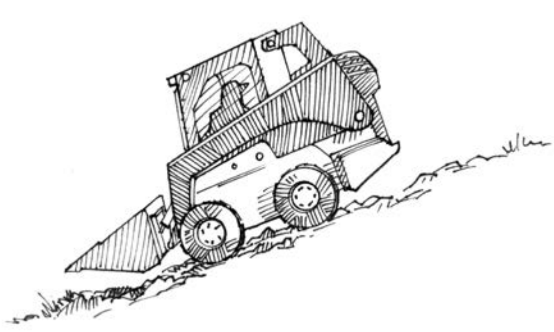


Figure 4.4 With no load in the bucket, the safest practice is to back up a steep slope. With a loaded bucket, drive up a steep slope with the bucket lowered. Credit: J. Mathison.

Starting and Stopping a Skid Steer

Operating a skid steer involves more than just jumping on, turning the key, and driving away. Skid steer manufacturers' safety decals warn operators to receive instruction before running the machine. Ask questions, get training, and read the operator's manual. Don't assume knowledge without training. Untrained operators can cause property damage, injury, and death..

This section explains how to safely start and stop a skid steer.

Interlock Control System

Skid steers are equipped with an interlock system, meaning the engine cannot be started unless the operator is physically in the seat with the seat belt fastened and/or the operator restraint engaged. The lift, tilt, and traction functions of the skid steer are electronically interlocked with the start function. A lighted display on the instrument panel will indicate if these systems are functional. **Do not attempt to disable the interlock system.**

Start Procedure

Use the bucket or attachment steps, grab handles, and safety treads to get on and off the skid steer. Always face the machine and maintain three points of contact when climbing on the skid steer.

Follow these steps to start:

1. Adjust seat position.
2. Fasten seat belt snugly or lower operator restraint bar, if so equipped.
3. Check foot pedals and hand controls are in a neutral position.
4. Set engine speed control to a ½-speed position.
5. Turn the key to start. If equipped with a cold temperature start (preheat), follow manufacturer's recommendations.

6. Allow the engine and transmission oil to warm for 5 minutes in cold weather.

Become familiar with all parts of the instrument panel.

Stopping the Skid Steer

Stopping the engine may not be as simple as turning off the ignition key. Some manufacturers may instruct the user to let the machine idle for a few minutes to cool the engine, hydraulics, and hydrostatic transmission fluid. Become familiar with what each machine requires for shut down. A supervisor should have this information readily available.

To stop the skid steer:

1. Idle back the engine speed to ½ throttle.
2. Set the parking brake.
3. Return lift arms and attachments to ground level (figure 4.5).
4. If attachments with hydraulic hoses are to be changed, relieve the pressure in the auxiliary hydraulic system either by turning the ignition key past stop for a few seconds until the engine is stopped, or by moving the hydraulic control lever back and forth several times after the engine is stopped. This will make the couplers easier to disconnect and connect.
5. Turn the ignition key to off (if it's not already).
6. Remove the key.
7. Raise the seat bar or remove the seat belt, and then dismount the machine using the grab handles while facing the machine. Maintain three points of contact when exiting the machine.

A supervisor will provide any additional requirements to follow in shutting down.

Skid Steer Ground Movement

Just as the name implies the skid steer (regardless of manufacturer) is steered by skidding the inside tires or rubber track while the outside drive wheels or track moves the machine in the direction of the skid. On soft soil or a manure-packed barn area, this happens easily. On a hard surface such as a roadway, the machine may grab the hard surface and bounce roughly.

This section discusses safe and efficient ground movement of a skid steer.

Forward, Back, Turn

Control levers are the "steering wheel" and ground movement control of a skid steer. Some skid steers use two levers (figure 4.6), while others may use a joystick type of control. Review the operator's manual to become familiar with the controls.

With a control lever system:

- Push forward on both levers to go forward.
- Pull both levers back (toward the operator) to go in reverse.
- Push on the left lever and pull back on the right lever to turn to the right.
- Push on the right lever and pull back on the left lever to turn to the left.

Figure 4.5 Return lift arm and skid steer attachments to ground level when stopping the machine. This allows a safe exit of the cab because you can't accidentally bump the control levers and lower the components on yourself or others. Credit: J. Mathison.

Note: Maintain full load engine speed above 2,900 rpm for efficient operation. Attempting to move the skid steer with low engine speed will often stall the engine.

Newer models of skid steers are equipped with joystick controls for movement, steering, and the hydraulic functions of raising and lowering the bucket or tilting the bucket forward and back. Joysticks have internationally accepted symbols to indicate their functions (figure 4.7). In some cases, there may be dual functions for the joystick, depending on the mode of use selected.

Figure 4.6 Control levers for moving or steering a skid steer are pushed forward, pulled back, or moved in some combination to "skid" the machine in the direction you wish to go. Notice the lap bar, which restrains the operator in the skid steer cab. Credit: J. Mathison.

Figure 4.7 Joystick controls reduce operator fatigue. The joystick can be rotated to many positions and has finger-tip button controls to move the skid steer, raise/lower lift arms, tip the bucket, and operate hydraulically powered accessories. Credit: J. Mathison.

Study the operation symbols or ask for an explanation of how the joystick or any other component is used.

When the skid steer control levers are released, they return to a neutral position and movement stops.

Safety Considerations

Once in the cab of the skid steer, operator vision is reduced both to the side and to the rear of the machine. Although no bystanders, children, pets, or livestock should be in the work zone, the operator must be aware of what is happening in the work area. Barn walls, supporting posts and beams, and other machinery can be damaged by careless skid steer use.

Be especially careful when backing the skid steer. Not all skid steers have mirrors to provide a view behind the equipment.

Does the skid steer have a reverse alarm to warn others the machine is backing up?

Attaching Accessories to Skid Steers

Skid steers can be used for a variety of tasks. Commonly, the skid steer is equipped with a scoop bucket to move soil, gravel, feed, and more. Attachments such as pallet forks, post-hole augers, soil preparation tools, and powered brooms require changing one of these accessories for another.

The following section discusses safe use of the skid steer quick attachment procedures.

Know the Parts

Boom-mounted attachments can be changed quickly. The parts of the system include:

- a pivoting mounting plate attached to the boom lift arms
- latch handles to lock the attachment to the pivoting mounting plate
- an attachment saddle (part of the attachment)

How to Attach an Accessory

To mount an attachment (figures 4.8 and 4.9), the latching handles must be in the fully "up" position. If not, the lock pins will not be retracted.

Align the skid steer mounting plate with the attachment's saddle by moving the skid steer while hydraulically raising or lowering the top of the mounting plate under the attachment saddle. Raise the mounting plate using the foot or hand lever controls until the back surface of the attachment rests against the mounting plate. The attachment can then be lowered with the bucket rolled forward (bucket does not touch the ground). It is ready to be locked into place.

To be safe, **turn off the engine, set the parking brake, and exit the skid steer.** Push the locking levers down firmly to engage the lock pins into the retaining tabs (figure 4.8).

Note: Some skid steers may be equipped with a push-button attachment locking system that electrically activates hydraulic pins from the operator's seat (figure 4.9).

Reverse the process to remove the attachment. When the attachment is free, lower the boom slightly and slowly back away from the attachment. Be sure the attachment is resting in a stable position.

Figure 4.8 The standard latch handle lock for securing the attachment to the skid steer mounting plate is circled. The latch handle must be placed completely down to lock it in place. Credit: J. Mathison.

Figure 4.9 If the skid steer loader mounting plate does not have latch handles to lock the attachment, look for the hydraulically operated pins that provide the locking mechanism, and for the hydraulic control that activates the lock pin. Credit: J. Mathison.

REMEMBER to remove the hydraulic lines before pulling away.

Using Hydraulic System Attachments on Skid Steers

The skid steer is a hydraulic machine (figures 4.10 and 4.11) powered by an engine. Everything is controlled by a hydraulic action--ground movement, steering, lift arm control, bucket position, and attachment operation. This section describes how to properly care for and use the skid steer and the hydraulically operated attachments.

Figure 4.10 A hydraulically operated tiller attachment is shown. Credit: J. Mathison.

Figure 4.11 Hydraulic hoses are attached to the skid steer at conveniently located quick connection points. Credit: J. Mathison.

Hydraulic Power

Oil is the common hydraulic fluid used with farm equipment. Review hydraulic oil system components information in Chapter 3.

Review the precautions needed when using hydraulics in the earlier section, “Implements with Hydraulic Components.” That section also includes information about connecting hydraulic hoses to couplers and disconnecting hydraulic hoses.

Removing a Hydraulic-Powered Attachment

Removing an hydraulically powered attachment involves the mechanical connection, and the hydraulic hoses as well. Follow these steps to disconnect the hydraulic hoses:

1. Make sure the attachment is in a stable position before disconnecting the mechanical linkage and hydraulic connectors.
2. With the lift boom arms lowered, move the hydraulic control levers back and forth a few times to release the static (load) pressure.
3. Push back on the lock ring.
4. Remove the hydraulic hoses from the couplings.
5. Replace the dust cap on each connector.
6. Hang the hoses on the equipment, keeping the hoses off the ground.

Seek assistance when learning these steps to prevent damage to the machine or injury.

All-Terrain Vehicles (ATVs)

They look like fun. They go fast. They travel in the woods. And they can kill and injure. What are they? They are ATVs and utility vehicles.

Consider these statistics:

- In a recent year, over 90,000 injuries and 650 deaths were reported in the United States for riders of ATVs.
- Children ages 10–14 account for 75% of the deaths from ATV injuries (figure 4.12).
- The U.S. Consumer Product Safety Commission reports that four of every 10 people treated in hospital emergency rooms for ATV-related injuries are younger than age 16.

- Nationally, over 30,000 children ages 14 and younger were treated in hospital emergency departments for ATV-related injuries (fractured bones and head and facial injuries) in a recent year.
- Over 90% of the ATV-related injuries to children under age 16 were on adult-sized ATVs.

This section discusses the safe use of ATVs and utility vehicles used for work and recreational purposes.

Figure 4.12 This safety decal shows that nobody under 12 should operate this ATV. Credit: J. Mathison.

As the name implies, all-terrain vehicles (ATVs) can travel almost anywhere. Rough terrain, steep slopes, rutted mountain roads, and muddy conditions make ATV use appealing. Sports and leisure-time enthusiasts, and workers use ATVs. ATVs have become a valuable tool for farm and ranch tasks.

ATVs are designed for work. Previous sections discussed tractor and skid steer stability. Review Chapter 2 and the skid steer sections of this chapter. Then consider these ATV design features:

- stability
- suspension
- drivelines
- power and speed

Stability—A four-wheel ATV is more stable than a three-wheel ATV. Heavy loads, steep slopes, and "popping the clutch" (quickly releasing the clutch while the vehicle is in motion) can cause the ATV to roll or flip backward. Turnovers occur when operator actions change the center of gravity. Note: The manufacture and sale of three-wheel ATVs has been banned in the U.S. since 1988.

Suspension—ATV suspension systems vary with the machine. Less expensive models may use only balloon tires for suspension. These ATVs can bounce and pitch sideways at high speeds. More expensive models use coil springs and shock absorbers to improve traction and steering control.

Drivelines—ATV drive mechanisms vary greatly. Several combinations of clutches, driveshafts, and differential locks are used. Higher speeds and sharp turns can increase the risk of side rollovers if the drive wheels are locked together for traction.

Power and speed—ATV engines vary in size from 100 cc to 700 cc or greater. Transmission gear ratios vary also. Some ATVs can travel over 50 mph. High-speed operation of the ATV increases the risk of loss of control and rollovers.

Remember, ATVs are not toys. They are powerful machines.

For safety reasons, dispose of three-wheeled ATVs. They turn over easily.

ATV Safety Training

Safety training for ATV use is the first step in being a qualified ATV operator. Local ATV dealers, clubs, and safety professionals from Cooperative Extension, state departments of conservation and natural resources, and farm organizations may offer safe ATV operation programs. The Specialty Vehicle Institute of America (SVIA) provides training as well. See svia.org for more information. At a minimum, use the operator's manual and the safety signs on the ATV to help educate yourself before using the machine.

Youth Readiness

Before purchasing an ATV for a youth, consider the child's physical and emotional development. Physical development includes size and strength, as well as visual perception and coordination. Emotional development (mental maturity) includes focus, discipline, reasoning, and decision-making ability. Parents often overestimate their own child's skills and abilities and may want a more objective evaluation of skills and abilities from another adult who is familiar with the child.

Physical Development

Have the child stand on the footrests of the ATV and grasp the handlebars. There should be at least 3 inches of clearance between the ATV seat and the seat of the youngster's pants. Have the child move the handlebars all the way to the right and to the left. Can they do this? Can the child operate the throttle and squeeze the brake lever with one hand, as these controls are intended to be used? Can the child shift their weight from side to side and from front to back and maintain their balance? One good measure of readiness to successfully ride an ATV is the ability to ride a bicycle. Can the child easily control a bicycle?

Table 4.1. Manufacturers' age and size recommendations for ATV operation.

Age of operator	ATV engine size
Under 6 years of age	Not recommended
6–11 years	Under 70 cc
12–15 years	70–90 cc
16 years and older	Over 90 cc

Emotional Development

The child's emotional maturity can be viewed from a perspective of personal discipline. Does the child have self-control, as shown by conforming to expected rules of behavior and awareness of the consequences of their actions? Riding an ATV safely requires following safety rules. Children who understand that unsafe behavior can result in injury or death show signs of emotional maturity. Adults should recognize that children have different maturity levels at any particular age. Just because some children are big for their age and can reach the controls of the ATV does not mean they will use mature judgment while riding one

Refer to the Ag Youth Work Guidelines from the National Children's Center for Rural and Agricultural Health and Safety (cultivatesafety.org), which help adults determine the readiness of youth to operate an ATV (cultivatesafety.org/wp-content/uploads/2017/09/2017-09-ATV-Riding-is-not-childs-play_300.png).

Drive Lines

ATVs with single speed, automatic transmissions are ideal for beginning riders. Power is easily controlled by the novice operator and an automatic clutch reduces the risk of "popping the clutch," which can result in a rear overturn. The automatic transmission offers reasonable speed for the learner. More sophisticated transmissions and drivelines are available for larger adult-sized machines (figure 4.13).

Figure 4.13 Adult-sized ATVs are not suitable for youth under age 16. The child's strength, skills, and maturity determine readiness to operate an ATV. ATVs are getting bigger and faster, ranging up to 700 cc and higher in engine size, weighing 600 or more pounds, with speeds exceeding 50 miles per hour. Credit: J. Mathison.

Supervisory Controls

Controls to help adults supervise beginning ATV riders are available, including throttle limiters, exhaust restrictors, and remote shut-off switches. A throttle limiter acts as a governor to maintain slower speeds. An exhaust restrictor reduces the engine's power. A remote shut-off switch may be an engine stop leash or tether an adult can pull to operate an engine shut-off switch. The remote can also be a more expensive electronic shut-off switch activated a greater distance away from the rider.

Carrier Racks

Carrier racks should not be installed on youth-size ATVs because the weight of objects or materials carried on the rack can shift the ATV's center of gravity and reduce its stability. The material on the rack may also block the youth's vision.

Understand the Risks

Some professional groups that advocate for youth safety believe youth under 16 years of age should not operate an ATV under any circumstances. The American Academy of Pediatrics and Safe Kids Worldwide organizations both recommend youth under age 16 should not operate an ATV of any size. Lay groups, such as Concerned Families for ATV Safety, have recently formed to advocate for stricter regulations regarding youth and ATV operation. The reasons given for this position include a youth's lack of judgment, maturity, and physical development; the inherent risks associated with ATV operation; an increased number of injuries to youth operators in recent years; and a lack of safety devices to protect children against injuries common to ATV riding. Considerable debate has been generated about whether the risk of injury to youth is sufficient to justify banning all ATV operation by youth under age 16. Parents are encouraged to stay informed of the arguments for and against ATV operation by youth (figure 4.14). Parents who allow their children to operate ATVs should be aware of the risks, provide for proper instruction, and monitor the safe use of the ATV for both work and recreation.

Figure 4.14 ATV use as a farm tool calls for strength to control the machine, skill to move and direct the machine, and maturity to understand the consequences of unsafe ATV use. An adult should supervise youth to help them learn how to work safely with an ATV. Credit: J. Mathison.

Design Features for All ATVs

In addition to considering design features specific to young riders, there are safety characteristics applicable to all ATVs. These include:

- **Suspension systems—**ATV suspension systems vary. Less expensive models may use only balloon tires for suspension. These ATVs can bounce and pitch sideways at high speeds. Some models have suspension systems only on the front wheels, while others have them on all four wheels. Some use only coil springs. Coil springs with shock absorbers provide the best traction, maximum control, and smoothest ride.

- **Brakes and footrests—**The ATV may have rear brakes only or have both front and rear brakes with independent controls. Children must be trained to operate the brake system properly to reduce the hazard of lost control due to sharp braking. The rear fenders and foot peg should be designed to make it difficult or impossible for the foot to slip off and be caught under the rear wheel.
- **Hot engine parts—**The muffler, exhaust, and other hot engine components should be located, or guarded, to prevent burns. The design should also prevent the buildup of dry trash near hot exhaust parts to reduce the risk of fire.

Injury from ATV use most often occurs because of

- extra passengers
- excessive speed
- road travel
- operating under the influence of alcohol and/or drugs

Operating an ATV

ATV operation is different from most other machines on the farm because of their design. Differences in operation are evident in turning, braking, climbing, and operating on various terrains.

Turning requires the operator to shift their weight for different types of turns. The operator should shift their body weight forward and toward the outside of the turn while making the turn. When turning at a higher speed, the operator should lean their upper body toward the inside of the turn while maintaining their weight on the outer footrest. When braking, gently and evenly apply the brakes.

Overturn incidents can occur on sloped terrains, so learn how to climb, descend, and operate in those situations. When climbing an incline, the operator should shift their body weight forward while keeping both of their feet on the footrests. If the ATV stalls or begins to drift backward, slowly apply the brakes, stop the machine, dismount, and slowly guide the ATV down off the slope while using the hand brakes to assist. When descending a slope, the operator should shift into a lower gear and drive downhill with their feet on the footrest, sitting toward the back of the operator's seat. When possible, an ATV should not be driven across steep slopes.

ATVs and Work Hazards

Protective Gear

The following protective gear is strongly recommended when riding an ATV:

- Wear a full face shield helmet. The helmet should fit snugly and securely. It should be labeled with the American National Standards Institute (ANSI) Z90.1 label.
- If a face shield is not part of the helmet, wear goggles or a separate face shield, especially at high speeds or in wooded terrain. The protective lens should carry the ANSI Z78.1 label.
- Over-the-ankle shoes with sturdy heels and soles are necessary to help keep feet on footrests.
- Gloves and long sleeves are needed for some jobs.
- Use lights, reflectors, and highly visible flags to increase the ATV's visibility.

ATV Overturns

A four-wheeler can do many of the tasks formerly assigned to the small farm tractor. Just as safe tractor operation is influenced by speed, terrain, and load size, so is the operation of an ATV. Steep or uneven terrain can cause an ATV to overturn. High speed, ditches, or large rocks increase the chance of the ATV being rolled or flipped during operation. Moving the ATV at a slower speed while the operator shifts their weight to the upper side of the slope reduces overturn risk. Selecting an ATV with coil springs and shock absorber suspension systems will help reduce bouncing and pitching from side to side.

Loading and Braking

Trailers loaded with firewood or feed may strain the pulling and braking capacity of the ATV. In addition, an attachment such as a tow-behind mower may have more weight than the braking power of the ATV can handle. Heavy loads can push ATVs down slopes with an increased risk of "jack knifing," sliding out of control, or rolling over. Carrier racks and pulled equipment increase the versatility of an ATV and enable users to complete a variety of jobs. To reduce the risk of a rear overturn, do not carry more than one-third of the ATV's weight on the rear carrier rack. Evenly divide the load between a front and rear carrier rack.

Do not tow a load that weighs more than the total weight of the ATV plus the operator, and only connect to the manufacturer's hitch point. Follow the manufacturer's recommendations when pulling or towing loaded carts, mowers, or other attachments.

The front and back brake of an ATV may operate independently or may have a linking design in which all four brakes work together. Using an ATV with a linked brake system reduces the risk of inappropriately or mistakenly applying the front or rear brake in a way that reduces control of the machine. Regardless of the braking system, learn how to brake at differing speeds and when pulling a load to reduce risk of losing control while stopping or turning. The ATV operator's manual can help explain the machine's braking capacity.

Unseen Obstacles

The ATV used for slower-moving agricultural work may also be used to herd livestock at higher speeds over uneven terrain. Herding animals with an ATV can be very hazardous. High speed travel across a field may cause the front end of the ATV to drop into a ditch or hole, or hit a rock. Quick or tight turns can cause the machine to roll. Rolling over or flipping the machine can result in severe injury or death.

ATV Maintenance

Routinely check the ATV to make sure it is running properly to reduce risk of injury and the potential to be stranded due to a malfunction. An ATV requires maintenance on the following key areas for the machine to work efficiently:

- **Tires—**Maintain the recommended air pressure in all tires because uneven pressure can cause the ATV to pull to one side. Nuts and bolts should be tightly secured.
- **Throttle—**Check the throttle to make sure it moves smoothly.
- **Brakes—**Check the brakes before every ride.
- **Lights—**Make sure the lights are working and wipe away any dirt to maintain optimal visibility.
- **Oil and fuel—**Examine the ATV for leaks and maintain recommended fluid levels.
- **Drive train and chassis—**Check for wear, leaks, and loose parts. Replace, tighten, and lubricate parts as needed.

ATVs and Public Roads

Some states regulate ATV use on or across public roads. Regulations may address the driver's minimum age for crossing a public road, specific locations for crossing, allowable reasons for crossing, and more. Check the state's transportation laws to see if and how ATV use on public roads is regulated.

Summary Guidelines for Safe ATV Use

- Understand principles of center of gravity and centrifugal force.
- Carrying passengers increases the risk of overturn injury and death. A second person changes the center of gravity of the machine and the machine's steering.
- Know the machine's limitations. Operating on steep terrain, pulling heavy loads, excessive speed, and "wheelie"-type starts can result in ATV turnover.
- Avoid public roads. ATVs are designed for off-road use. The risk for rollovers increases in ATVs driven on hard road surfaces.
- Check the state's vehicle code for use of the ATV as an agricultural machine. Use of the ATV for agricultural purposes and only incidental road travel may be permitted.
- Check and fill the gas tank to avoid being stranded.
- Avoid driving at high speeds and jerking the steering.
- Be aware of rough terrain. Proceed slowly.
- Do not operate at night or in bad weather.
- Stay on trails for safety and to protect habitat. Scout trails first for hazards.
- Carry less than one-third the weight of the ATV on the rear carrier rack.
- Keep towed load amounts less than the combined weight of the ATV and operator.
- Hitch only to manufacturer-supplied hitch points to maintain a safe angle of pull.
- Never operate an ATV under the influence of alcohol or other drugs.

Utility Vehicles

Utility vehicles are similar to golf carts except they are fitted with cargo boxes to carry work materials. Utility vehicles can have four, five, or six wheels, depending upon their use. They weigh about 1,000 pounds and can carry several hundred pounds of cargo. They can be diesel-, gasoline-, electric-, or hydrogen fuel cell-powered.

Like other farm machines, the utility vehicle is made for work purposes. It's a convenient transport for small jobs, such as hauling feed, mulch materials, and supplies. Like an ATV, the utility vehicle is a tool and not a toy.

Safe operation of a utility vehicle requires the same safe work habits as are used with tractors, skid steer loaders, and ATVs.

Safe Utility Vehicle Use

Use the operator's manual and safety signs/decals found on the machine to learn how the utility vehicle operates and what safety practices to observe. A successful operator becomes familiar with a machine before attempting to use it. If no training materials can be found, ask a qualified operator to demonstrate what to do.

The following safety practices should be followed in operating a utility vehicle:

- Some manufacturers' specifications suggest no operator younger than age 16 should be permitted to operate a utility vehicle.
- With increased amounts of cargo, the utility vehicle's center of gravity is raised and shifts toward the rear. Risk of an overturn increases (figure 4.15). Drive slowly and turn smoothly.
- To prevent overturns, secure the load to prevent sideways shifting.
- Avoid driving on steep slopes. It is safer to drive uphill or downhill rather than across a slope. Avoid sharp turns to

prevent overturns. Drive to the top or bottom of a slope to make a turn. When approaching a downhill slope, reduce speed before reaching the slope. This will help reduce wear on the brakes.
- Reduce speed over rough terrain to prevent the utility vehicle from bouncing. Operators and riders have been thrown from utility vehicles in this situation.
- A second rider should occupy the passenger seat. Do not permit extra riders to ride in the cargo box. Use the handholds. If the utility vehicle has a roll bar, buckle the seat belt.
- Do not drive near ditches or embankments. Remember, if the ditch is 6 feet deep, stay back from the edge by at least 6 feet.
- Use information about tractors, skid steer loaders, and ATVs to safely operate a utility vehicle.

As with all machinery, use the device as it was designed.

Utility vehicles can overturn at high speeds and while making sharp turns.

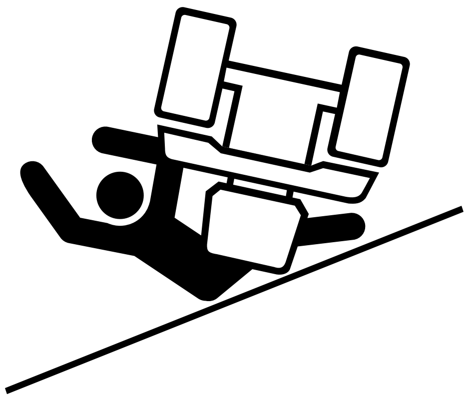


Figure 4.15 A utility vehicle is versatile. It can do the smaller jobs that a pickup truck may be unsuited to do. But remember that the utility vehicle has limitations. Avoid steep banks. Utility vehicles can easily overturn. The driver must know the machine and the work area to reduce potential risk of injury. Credit: Association of Equipment Manufacturers.

Telehandlers

Large volumes of agricultural crops and materials stored in large facilities have created the need for equipment that can reach higher and farther. Telehandlers (figure 4.16) can lift up to 10,000 pounds, and their booms can extend outward 30 to 40 feet. Because they could be mistakenly overloaded or operated on sloped ground, a thorough understanding of telehandler capabilities is a necessary before use.

What Is a Telehandler?

Telehandlers are also called material handlers. Technically, telehandlers are r**ough-terrain variable-reach forklifts** and are considered a class-7 powered industrial truck. They operate entirely unlike a forklift.

Figure 4.16 Telehandlers can handle large and weighty agricultural materials. Credit: J. Mathison.

The telehandler requires as much understanding of stability as operating a tractor does.

Boom—The telescopic (variable-reach) boom can extend or retract 30 to 40 feet and elevate to an angle of 70 degrees from horizontal. Capacity may reach 10,000 pounds. Booms are marked in increments to alert the operator how far the boom is extended (figure 4.17).

Frame tilt—When operated on sloping ground, the telehandler frame can be altered relative to the ground by 10–15 degrees in either direction to keep the boom vertical in position. A frame tilt/level indicator (figure 4.18) is mounted in the cab to assist the operator in keeping the frame level relative to the slope.

Steering—Most telehandlers have three steering options for various work locations. These include:

- Front wheel steering, in which the front wheels turn like cars.
- Circle steering, which allows the front and rear wheels to react in opposite directions to permit a tight turning radius.
- Crab steering, which creates the ability to move diagonally over the ground as all four wheels react in the same direction as the steering wheel is turned.

Carriage—This is the lifting attachment(s), which can tilt farther forward and backward than a forklift, and can rotate slightly to tilt a load into an unusual space.

Outriggers—Larger telehandlers may be equipped with outriggers for heavy load stability when loaders are operated from a stationary position (figure 4.19).

Know how to interpret the load capacity charts found in the operator's cab.

Load Capacity

Telehandler load capacity depends upon many variables. Lifting large loads to high storage areas may exceed the capacity of a machine. **Each load and each position to which the load is lifted or moved can change the center of gravity and stability of the telehandler.**

Each of the following items, if handled incorrectly, can lead to a mishap:

- boom angle and extension
- load weight
- use of outriggers, if equipped
- rubber tires vs. rigid tires
- grade, or slope
- wind
- lifting attachment

Figure 4.17 As the boom is extended, a letter or number marking (circled) is revealed with references in the operator's cab to give restrictions on how much weight can be lifted safely. A boom angle indicator is included. Credit: J. Mathison.

Figure 4.18 A close-up of the boom angle indicator, which is typically visible to the operator from the cab seat. A similar indicator is found on the instrument panel to show frame angle (

Figure 4.19 If the telehandler is equipped with outriggers, use them to stabilize the machine during stationary use. Credit: J. Mathison.

The operator's station has several charts to reference load capacity versus boom extension, boom angle, and frame angle. Use these charts to determine maximum machine angles and settings before lifting a load.

Start-Up Procedure

Following a training period on the telehandler, follow the steps below to start the machine.

1. Complete a pre-inspection of the machine.
2. Fasten your safety belt.
3. Ensure that all controls are in the neutral position.
4. Turn the ignition switch to its preheat position if so equipped; start the engine when signaled.
5. Warm up the engine at half throttle.
6. Close the cab door.
7. Check the lights, backup alarm, and horn.

Moving/Using the Telehandler

Before moving the telehandler:

- Check the steering and braking controls.
- Be sure the boom extension and leveling controls are operational, and test them on level ground.
- Lower the outriggers before lifting a load.
- Practice using the lift and leveling controls before moving a load.
- Check for other personnel and machines in the area.
- Plan telehandler travel on days that have the best visibility.
- Keep the boom retracted and as close to the ground as possible.
- Start, stop, turn, and brake smoothly.
- Slow down before reaching hazards such as turns and uneven surfaces.
- Avoid overhead utility lines to prevent electrocution.
- Raise the outriggers before moving the machine.

If the telehandler has outriggers, be sure they are lowered during lifting (for stability) and then raised for travel.

Shut-Down Procedure

When the work is completed, park in a safe location on level ground away from other equipment and traffic (figure 4.20). Follow these steps:

1. Apply the park brake.
2. Shift the transmission to neutral.
3. Retract the boom, and then lower the boom and any attachments.
4. Let the engine idle for 3–5 minutes to cool.
5. Shut off the engine and remove the key.
6. Remove your seat belt.
7. Use the grab handles and exit the machine safely.
8. Block the wheels if parking on a slope is unavoidable.
9. Some models may have a master electrical switch to disconnect the battery from service. If so, disconnect the battery.

Figure 4.20 When finished with work, park on level ground with the boom retracted and lowered. Set the park brake. Remove the keys so that an untrained person cannot move the machine. Credit: J. Mathison.

Tractor Front-End Loader

A front-end loader (high-lift with bucket or other accessories) mounted on a tractor is a valuable tool for lifting, moving, dragging, and pushing items such as soil, gravel, large round bales, equipment parts, and road repair materials. Using the front-end loader requires an understanding of machine capacity limitations and center of gravity, and an awareness of work surroundings. This section discusses using a front-end loader mounted on a farm tractor.

Front-End Loader Components

Often the front-end loader is used on a tractor dedicated to that attachment. In other cases, the front-end loader is parked on its support legs and must be attached to the tractor's frame and hydraulic system for use. The tractor will have mounting points to attach the front-end loader (figure 4.21).

Figure 4.21 Front-end loaders may be parked and then will need to be mounted to the tractor you will operate. Components include: A. The tower columns, which are hooked to the tractor's mid-frame and often serve as the support legs. Some smaller units may have a light-duty rod that is inserted as the support leg. B. Bar and saddle, which hooks to the tractor's front frame. C. The lift arms and frame. D. The hydraulic control system. Study the components before attempting to connect to the tractor. Tighten all connections securely. Credit: J. Mathison.

Make sure all components are secure before operating the front-end loader.

Center of Gravity

The tractor's center of gravity is engineered to maintain stable contact with the ground. Anything that moves the center of gravity outside of the stability baseline can lead to a tractor overturn. Raising the front-end loader bucket with or without a load raises the center of gravity (figure 4.22). With the center of gravity raised, an overturn can occur more easily while operating on uneven surfaces, or on rough roadways. Always travel with the bucket as low to the ground as possible. If working on a hill with a loaded bucket, travel forward uphill and backwards downhill. Review Chapter 2, Tractor Hazards, Tractor Stability, and Using the Tractor Safely.

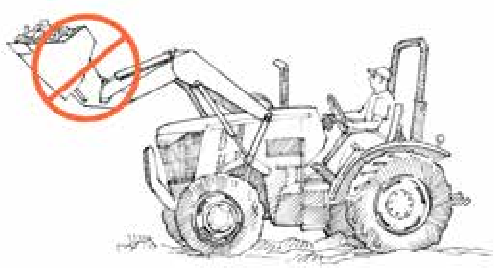


Figure 4.22 When operating the front-end loader, keep the loaded or empty bucket as low to the ground as possible while in transport. Sideways rollovers can result if you travel with the bucket in the up position. Credit: J. Mathison.

Load Capacity

Agricultural inputs of feed, fertilizer, chemical bulk packs, and large-package hay bales have all become heavier and bulkier. All loads, whether heavy or light, can change the center of gravity of any tractor when lifted with a front-end loader. Thus, the tractor can be more easily tipped. Loads can also roll back onto the operator. To reduce risk of overturn or load rollback follow these tips:

- Use a wide front-end tractor for loader work to improve stability, rather than a narrow-front wheel tractor.
- Always use a tractor with a rollover protection structure (ROPS) and a seat belt for front-end loader work. A tractor with an enclosed ROPS cab is best.
- Understand that some loads are too heavy for the tractor to lift. Know the machine's capacity.

- Make sure the load is not bigger than the bucket. Load rollback can result.
- Use several trips to complete the work rather than trying to move too much material in one load.
- Keep loads close to the ground during transport to maintain a low center of gravity.
- Avoid slopes or rough terrain when transporting a load with a front-end loader.
- If a load must be carried high, move slowly and smoothly; avoid jerky movements (figure 4.23).
- Consider whether the tractor needs more ballast (weight) added to the rear before continuing to use it. If the tractor feels as though it is tipping during loading, reduce the load or add ballast to the rear end of the tractor.

Figure 4.23 Extending the front-end loader with the bucket or fork attachment moves bulky loads easily, but also raises the tractor's center of gravity. This can allow the tractor to tip sideways more easily. Use the operator's manual to determine safe loading capacity. Credit: J. Mathison.

Heavy loads lifted high can tip the tractor. Materials can roll off the back of the bucket if the load is too large.

Pinch and Crush Points

Front-end loader lift arms move close to the tractor frame and mounting points. Other close-fitting parts include the connections between the bucket and the lift frame or other attachments and the frame. These parts roll back during loading. **These are places where a person can be pinched or crushed.** To avoid pinching and crushing injuries:

- Be sure bystanders or helpers move away from the front-end loader during use.
- Before making repairs, lower the front-end loader, shut off the engine, and relieve the hydraulic pressure by moving the hydraulic control lever back and forth a few times.

Work Surroundings

Farm equipment operators must be aware of their surroundings as they go about their work. Before operating the front-end loader, check the following items:

- location of fellow workers
- location of children and pets
- location of livestock and livestock equipment
- location of building corners and overhangs
- location of utility lines (figure 4.24)

Equipment operators can become so focused on their work that they overlook people or animals entering the work zone. Children, bystanders, and pets may not understand or anticipate equipment movements. Avoid working too near buildings, if possible. Most importantly, know the location of overhead power utility lines. To avoid electrocution, do not use the front-end loader bucket to dig into the ground unless underground utilities have been located and marked.

No. 1 rule: Keep it low and drive slow(ly).

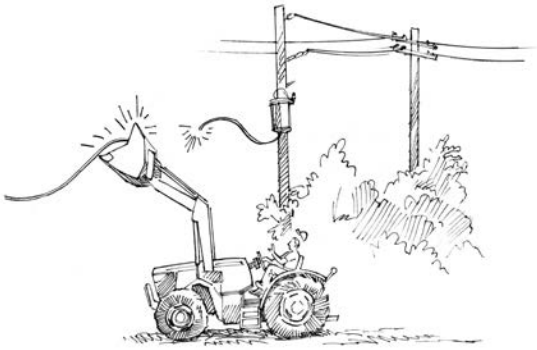


Figure 4.24 To prevent electrocution, lower the front-end loader bucket to avoid power lines crossing the work area. Credit: J. Mathison.

Figure 4.25 Augers are found in many places. Augers move grain and feedstuffs into bins and processors and carry these materials to feed carts, grinders-mixers, and feed bunks. The moving parts can pull a victim into the machine. Augers should be guarded as shown. Auger guards must be kept in safe condition. Credit: Central States Center for Agricultural Safety and Health.

Augers and Elevators

Talk to an older farmer and they may tell stories about shoveling corn into the corn crib or feed grinder. Those days are over. Augers and elevators quickly and efficiently move grain, processed feeds, and forages to improve farm productivity. These devices have moving parts with pinch points and wrap points that must be guarded. After years of use, guards may be damaged or missing. Homemade elevators may have never been guarded. **The risk of being pulled into and entangled in the moving parts of unguarded machines is high.**

This section will explain how to avoid an injury or fatality due to auger and elevator hazards. Review the Mechanical Hazards section in Chapter 1.

How an Auger Works

The auger (figures 4.25 and 4.26) is a shaft with an attached screw-thread fluting made from metal or hard plastic. The end of the auger can be placed into a grain pile, bin, or wagon to move material very quickly. The turning part (auger) and the auger tube move together closely enough to snag feet, hands, or loose clothing. Entanglement, amputation, or death can occur. Elevator belts and pulleys or chains and sprockets can entangle the operator if guards are not in place.

Figure 4.26 A total mix ration (TMR) mixing wagon loads from the top by high-lift bucket. This is not a normal work position and because of the distance away from the operator is considered to be guarded by location. DO NOT ENTER this mixing space, which has two augers moving close together. A hazard is guarded by location when it is guarded by other parts or components of the machine that are not themselves guards, or when the hazard is beyond the safety distance. The high sides of the mixing wagon form a barrier to prevent the hazardous area from being reached inadvertently. Credit: J. Mathison.

Safely Guarding Augers

Engineering Standards by the American Society of Agricultural and Biological Engineers (ASABE) call for exposed auger flights to be guarded.

- Guards are to cover the top 180 degrees of the inlet area and extend a minimum of 2.5 inches above and below the exposed auger flights.
- Openings in the guard for the free flow of material shall be no larger than 4.75 inches for the largest dimension opening, and the area of the opening shall be no larger than 10 square inches.
- The guard should be no closer than 2.5 inches to the rotating auger flights and able to support a 270-pound person.
- Drag-type augers and grating-type guards are to have these standard dimensions as well.

Even when an auger is guarded according to ASABE standard, a small hand may be able to slip between the guard openings and be caught in an operating auger. **Keep hands and feet away from operating augers.**

In addition, safety signs should be in place to inform the operator of the rotating parts hazards and to warn against modification or removal of guards.

With years of use, auger guards can become damaged. This increases the risk an injury or fatality can occur. If auger guards are damaged or missing, report to someone who can repair or replace them.

Augers must be guarded. Keep guards in safe condition.

Elevators

Elevators (figure 4.27) carry ear corn, small grains, and hay and straw bales using a chain with webbing or flights, or sometimes with an endless belt. The mechanism may be powered by an electric motor, gas engine, or tractor power takeoff (PTO) shaft.

Commercial elevators may be purchased without a power source, which the end-user then supplies. The end-user may not have installed a guard around the belt and pulley or chain and sprocket drive system. The risk of entanglement increases when moving parts are unguarded.

Elevators are not ladders or people movers.

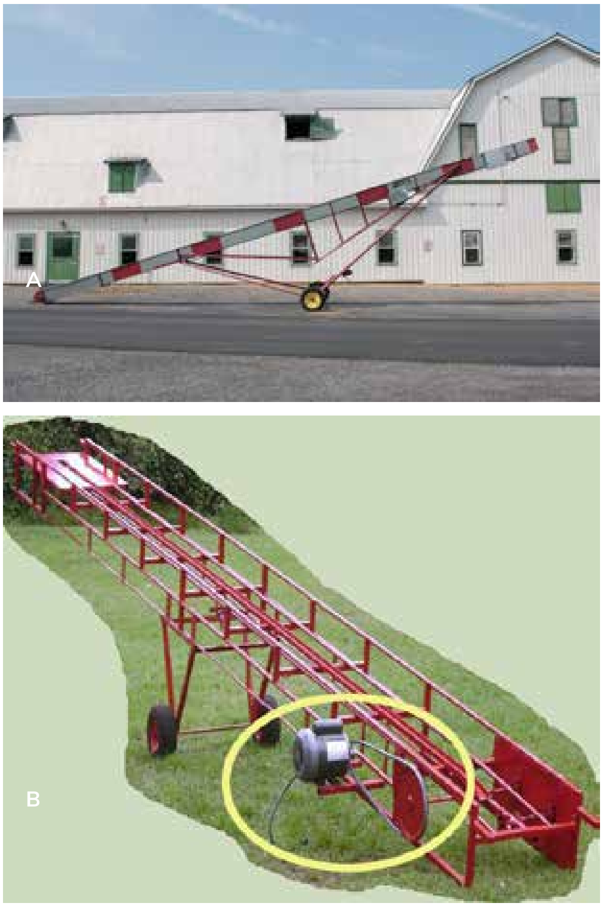


Figure 4.27a and b (a) An elevator that can be used for a variety of agricultural products. (b) An elevator for moving hay or straw. Note the turning parts (motor pulley, belt, and drive pulley), as well as the open frame structure. Homemade elevators may be made with solid wooden sides and bottom. Because of the unguarded pulleys and belt, this is an unsafe drive mechanism. Credit: (a) PSU Ag Safety (b) J. Mathison.

Other Considerations

Augers and elevators move large quantities of material. The weight of the material may not be evenly distributed in the auger or on the elevator. They can up-end (tip forward) easily if not secured by an anchor at the intake end or by supports at the discharge end.

Remember when the job is done and the auger or elevator is to be moved, the auger tube may still have grain or feed in it, and the elevator can be top-heavy. Empty the auger tube before transporting the auger to prevent tipping. Lower the elevator or auger to reduce the center of gravity and prevent tipping forward or sideways.

Augers and elevators must be lowered to a transport position to avoid contact with power lines around the farm (figure 4.28). Electrocution can result if contact is made with the wires.

Safety Practices for Augers and Elevators

- Read and understand the operator's manual before using the auger or elevator.
- Ask a supervisor to demonstrate how to use the auger or elevator. They should provide support when jobs are first assigned.
- Keep all safety shields and devices in place.
- Make sure the area is clear of bystanders before operating the auger or elevator.
- Keep hands, feet, and clothing away from moving parts.
- Shut off power to adjust, service, or clean the auger or elevator.
- To prevent a fire, clear crop debris and dust from accumulating around a motor or engine. Dust can catch fire.
- Do not ride an elevator to the top of the barn or bin. Falls and entanglement can occur.
- Remember, a small internal combustion engine used as the power source for an auger or an elevator can be a source of heat or sparks, which may ignite hay, straw, or grain dust that accumulates around the engine.
- Keep a 10-pound ABC fire extinguisher available for emergency use.

Figure 4.28 Lower an auger or elevator for transport to reduce risk of contacting overhead power lines. Credit: J. Mathison.

Observe the location of overhead power lines before moving augers and elevators.

Silage Defacers

Census data show that American agriculture is growing in scope. Expanding livestock feeding operations require the handling of ever larger quantities of forage and silage. Silage stored in trenches, bunkers, and drive-over piles is now common. Trenches, bunkers and piles can contain thousands of tons of silage often packed to depths of 20 feet or more (figure 4.29).

Figure 4.29 This loader may be large enough for most jobs, but it cannot reach the top of this silage pile to evenly remove the silage each day. Collapse of the silage face can entrap a worker when the silage face caves in from being undercut. Credit: J. Mathison.

With these mountains of compacted silage comes the need for equipment to remove it for feeding. This section addresses the safe use of silage defacers.

The Work of a Silage Defacer

Silage defacers (figure 4.30) have been designed to loosen silage from tightly compacted trenches, bunkers, and piles. Hydraulic-powered versions and toothed, nonrotating defacers are available. The defacer, when placed on an extendable boom, can reach to the top of the pile.

The typical farm's feeding equipment may be too small to reach the top of a massive silage face. Continual removal at the bottom of the face causes undercutting, which can lead to a dangerous collapse of the silage. Several deaths have been reported across the United States due to silage face collapse and suffocation of the victim. One death involved a youth caught in the blades of a silage defacer.

Understanding the purpose of these machines involves two major considerations:

- Maintaining a consistent supply of high quality silage to the herd means removing enough silage to stay ahead of spoilage without excessive disruption of the tight pack of the silage.
- Preventing a silage pile collapse due to continuous undercutting of the bottom of the silage feed-out face.

Figure 4.30 A hydraulic-powered, revolving-type silage defacer mounted to a skid-steer is used to evenly remove the silage from the entire feed-out face of the silage. The construction of the defacer allows the operator to view the task easily. Credit: J. Mathison.

Silage feed-out faces can cave in and trap workers.

Using the Silage Defacer Safely

Follow these suggestions to safely use the silage defacer:

- Understand how the defacer works by studying the operator's manual.
- Clear the work area of all bystanders.
- Operate the defacer only from the operator's station.
- Position the defacer at the top of the silage feed-out face before engaging the defacer motor to prevent undercutting, which can lead to silage collapse.
- When the defacer has reached full speed, lower the unit slowly while cutting through to the correct depth, usually 1 to 3 inches on each pass.
- Keep the defacer level while lowering to maintain an even cut.
- Do not force the defacer down through the silage.
- Avoid contact with bunker walls and concrete or asphalt floor.
- Do not leave the operator's station until the unit has been lowered and the tines have stopped moving.
- Service the unit only when it is completely stopped and the keys have been removed from the ignition switch.

Never leave the operator's station while the defacer blades are turning.

Silage-Bagging and Bale-Wrapping Equipment

Forage crops are often stored in large plastic bags or wrapped in plastic rather than placed in silos, barns, or sheds. Crop harvest efficiency and storage costs have driven this trend. Silage-bagging and bale-wrapping machines are designed to rapidly store large quantities of forage. Because PTO and hydraulic systems provide the power to operate this equipment, the operator must understand the hazards that can occur during use of the silage bagger or bale wrapper.

The Silage Bagger

Silo bags are filled using a machine that looks like a sled with a large plastic bag attached to one end. The silage bagger (figure 4.31) is driven from the PTO of the bagging tractor, which remains in neutral and is gradually pushed forward as the silage bag is filled. Bags are filled in a straight line as the tractor's steering is held straight. There may not be a person sitting on the tractor during the bagging operation.

The bagging tractor's PTO is in operation for the entire fill period. Operators and bystanders are at risk in the area close to the turning PTO.

The plastic silage bag is loaded like any other silo, except the forage wagon being unloaded is moved forward with the bag loader as the plastic bag is fed from the bagging machine. A table-like attachment with spiral-shaped teeth moves the crop from the dump platform into the throat of the bagger equipment.

To pack the bag tightly, cables with springs are attached to the back of the bag being filled and packing is controlled by a large brake shoe–type pressure regulator (figure 4.32). Once filled, this pressure is released and the rear end gate falls to the ground.

Bystanders must be kept away from the filling operation.

Figure 4.31 Silage bagging equipment is driven by the PTO of the bagging tractor. A second tractor or dump truck and unloading equipment is operated in close proximity to the tractor and bagging equipment and must be moved slowly forward as the bag is filled. The bag being filled is directly behind the tractor. Credit: J. Mathison.

Figure 4.32 From the rear of the bagging equipment, the endgate and cable braking system are shown. A large industrial disc brake(s) (see inset) and a simple brake hand pump and brake pressure gauge control the rate of cable release. Silage bags may have convenient "stretch gauges" marked continually along the bag to ensure packing consistency. Tension may be preset with experience or manually controlled during fill. Tension on the cable is released from the endgate when the bag is filled, and the endgate can drop heavily to the ground. The close quarters between the bagging equipment and the wagon or truck being unloaded raise the potential for injury. Turning parts can snag loose clothes very quickly, and the tractor operator's visibility of someone in this space is reduced. Credit: PSU Ag Safety.

A young man jumped from the bagging tractor, caught his clothes on the gear shift, and was thrown beneath the turning wheels of the tractor, which sat spinning its tires with him trapped beneath.

Safe Practices Around Forage Bagging Equipment

Although silage-bagging operations have reduced the potential for falls from an upright silo, other safety hazards exist with this equipment. Only youth aged 14 and older should work with silage-bagging equipment.

Equipment used for unloading is powered by tractors stationed next to each other. Access to this area should be limited. Observation and operation of the unloading equipment should be done from outside this high-hazard zone.

All safety practices involved with agricultural equipment relate to silage-bagging equipment as well. Review the Mechanical Hazards section in Chapter 1.

Remember these safety points:

- Ask a supervisor to demonstrate how the machine is operated and what can go wrong.
- Remember to avoid loose or torn clothing, which easily becomes entangled.
- Keep shields in place.
- Do not step over turning PTO shafts.
- Stop the machine to unplug any jamming from feeding off the unloading table too rapidly or from plastic wrap that may become entangled.
- Know where the other workers are located and communicate equipment movement with them.
- Never leave the bagger or bagger–tractor running unattended.
- Keep children and other bystanders away from the work area.
- Understand silo gases can accumulate near bag openings if the fill process will occur over several days.
- When unloading silage from the bag, the front-end loader must be carried low to the ground to prevent tractor rollover.

RECOGNIZE THE HAZARD ZONE:
The space between the wagon or truck being unloaded and the bag being filled is a hazard zone.

The Bale Wrapper

Round hay bales may be wrapped in the baling machine itself, but often bales are dropped in the field and wrapped later. The bale wrapper shown in figure 4.33 uses a hydraulic lift arm to lift the bale from the field and place it on the wrap table. Plastic film is applied as the bale is rolled and rotated on a support table. Controls may be manual, hydraulic, or joystick-activated from the operator's seat.

When wrapped, the plastic is sheared, the is bale dropped from the support table, and the process is repeated. Dozens of bales per hour can be wrapped.

Figure 4.33 The bale wrapper uses hydraulic components to rotate the bale in two directions to wrap the plastic film snugly. Once covered, a shear arm cuts the plastic, the bale is dropped to the ground, and another bale is lifted into place for wrapping. Because this is done from the tractor seat, the operator is physically removed from machine hazards. Keep children and bystanders away from the wrapping operation. Credit: J. Mathison.

Working Safely with Bale-Wrapping Equipment

Engineering design keeps the operator of the bale-wrapping machine at a safe distance from the turning wrap table and drop point of the wrapped bale. Yet hazards exist and injuries occur while using a bale wrapper.

Hydraulic power removes many turning parts, but may expose the operator to hydraulic-related hazards. In addition to hot hydraulic fluid, hoses can develop pin-hole size leaks under pressure. Handling or inspecting hoses for leaks must be done with a piece of cardboard, a mirror, or a small piece of glass. **Never check for hydraulic leaks with fingers or hands. Hydraulic oil injected into the body must be immediately treated as a medical emergency.**

The lift arm device and support table are moving parts with pinch point or shear point hazards. Understand that these areas can cause injury or death.

Round bales are heavy. Once wrapped, they are dropped to the ground by machine power and gravity. Crushing incidents are possible and round bales can roll.

Keep children and bystanders away from the bale wrapper during its operation.

When moving wrapped hay bales, remember that heavy loads change the center of gravity of the tractor or skid steer, and rollovers can occur.

As with all machinery, be aware of the surroundings. Bystanders are at risk.

ACTIVITY 4.1

Starting and Stopping a Skid Steer

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to safely start and stop a skid steer and understand the restricted field of vision around a skid steer.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–6, can safely start and stop a skid steer, and understands the restricted field of vision around a skid steer.

Life Skills: Comprehension, skid steer operation

Tags: Skid steer

Time Needed: 1 hour, depending on the experience of students and the number of tractors and instructors available

Materials List:

- at least two skid steers, preferably one lever-controlled and one joystick-controlled, with operator's manuals
- cones or other markers
- copies of Let's Do It

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Delineate a space for part 5, one with a few different kinds of obstacles

Introduction: Review the Skid Steers section of Chapter 4.

Opening Questions: Name some farm jobs for which you might use a skid steer. Discuss some hazards that require caution when using a skid steer. This activity and the next will help you learn to use a skid steer safely.

LET'S DO IT!

ACTIVITY 4.1

Starting and Stopping a Skid Steer

1. If you have never operated a skid steer, sit in a skid steer cab to observe what controls are available and where they are located. This may also be done at an equipment dealership. Later, review the operator's manual for the skid steer you will operate to study the controls and instrument gauges as you sit in the operator's position.
2. Practice starting and shutting off the skid steer. Practice using the lift and traction controls while sitting in the machine with the parking brake set.
3. Learn where the lift arm locking pins are located on the skid steer.
4. Describe to your leader or a group member the conditions that must be met for an operator to exit the skid steer cab.
5. Inspect a work area (preferably one you are assigned to) for hidden obstacles, building parts that are close to the work area, overhead utility lines, ditches, and any other potential problem that might interfere with moving the skid steer as you work.
6. Sit in the skid steer facing forward with the machine off. Have someone approach the skid steer from different angles, and signal when you can see them. Mark these positions with cones or other markers and discuss the restricted field of vision around the machine. Repeat the exercise, but use a caution (traffic) cone and see how the field of vision changes. What does the restricted field of vision tell you about a small child, pet, or bystander in that area as you operate the skid steer?

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 4.2

Driving and Operating a Skid Steer

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to drive a skid steer safely.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–3, and can drive a skid steer safely.

Life Skills: Comprehension, skid steer operation

Tags: Skid steer

Time Needed: 1.5 hours

Materials List:

- at least two skid steers, preferably one controlled by hand and foot levers and one controlled by joystick, with operator's manuals
- cones or other markers to delineate skid steer driving course
- material to move with the load bucket
- truck with bed (optional, for use in practicing with load bucket)
- blindfold
- pens/pencils
- copies of Let's Do It

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Scout out an open, flat area for beginning skid steer driving. Set up a course for the youth to practice moving the skid steer around and through obstacles. Be sure that one part of the obstacle course involves using the load bucket. You could use the National Safe Tractor and Machinery Operation Program (NSTMOP) Skills and Driving Test Layout Map in Activity 2.9 Tractor Stability, if you wish.

Introduction: Review the Skid Steers section of Chapter 4.

Opening Questions: Do you know or have you heard of anyone who's had an accident involving a skid steer? If so, how much experience did the operator have? Summarize what happened and how the accident might have been prevented.

Variation: You could also search the internet to find an incident to analyze.

LET'S DO IT!

ACTIVITY 4.2

Driving and Operating a Skid Steer

1. Match the skid steer control position (in the left-hand column) with the resulting action to be expected (in the right-hand column).

		Skid steer control position	Resulting action to be expected
A.	_____	Left foot pedal pushed forward with toes	1. Skid steer spins in circles to the left
B.	_____	Left foot pedal pushed downward with heel	2. Lift arm raises
C.	_____	Right foot pedal pushed forward with toes	3. Bucket tilts forward to unload
D.	_____	Right foot pedal pushed downward with heel	4. Bucket rolls back to load
E.	_____	Right hand control lever pushed fully forward, left hand control lever pulled fully back	5. Lift arm lowers
F.	_____	Right hand control lever pulled backward, left hand control lever pulled back	6. Skid steer moves forward
G.	_____	Right hand control lever pushed fully forward, left hand control lever pushed fully forward	7. Skid steer moves in reverse

2. Determine how a joystick-controlled skid steer performs the functions in Question 1. Summarize your answers here.

____

____

____

____

3. With supervision, drive the skid steer course to practice steering and using the load bucket.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 4.3

Skid Steer Attachments

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to connect skid steer attachments safely, and to connect and use skid steer hydraulically operated attachments safely.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–8, can connect skid steer attachments safely, and can connect and use hydraulically operated attachments safely.

Life Skills: Comprehension, skid steer operation, attachments

Tags: Skid steer

Time Needed: 1.5 hours, depending on the experience of students and the number of skid steers and instructors available

Materials List:

- at least two skid steers, preferably one controlled by hand and foot levers and one joystick-controlled, with operator's manuals
- at least two skid steer attachments, preferably different kinds
- material for load-moving practice (preferably sand, sawdust, or mulch)
- safety glasses
- pens/pencils
- copies of Let's Do It
- blindfold(s)

Space: Barn, work shed, or farmyard

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Have the youth conduct a safety inspection of the skid steer before beginning the activities. With adult supervision, they should verify that the hydraulic couplers are firmly attached, the hoses are in good shape, and there are no hydraulic leaks. They should also inspect the latching mechanism to be sure the bucket is firmly attached and locked into place.

Introduction: Review the Skid Steers section of Chapter 4.

Opening Questions: To operate a skid steer, what do you have to know besides how to drive it? Which attachments might you need to do different jobs? Are all skid steer attachments attached the same way?

ACTIVITY 4.3

Skid Steer Attachments

LET'S DO IT!

1. Ask your leader or another adult or supervisor to demonstrate how the bucket attachment is removed and reattached on the skid steer.
2. Practice removing and re-attaching the skid steer load bucket or other attachment. Pay special attention to the lower bucket tabs where the lock pins hold the bucket or attachment in place. The lock pins must fit into the lower bucket or attachment tabs to be secure. Do not raise the attachment if these lock pins are not engaged in the attachment's lower tabs.
3. Identify all the hydraulic system components that are external to the skid steer. Name the parts and their purpose to a friend, leader, or supervisor.
4. Use the operator's manual to find the location of the hydraulic fluid fill and/or check point, and check the hydraulic fluid level of a skid steer.
5. Practice connecting the hydraulic hoses to the skid steer coupler multiple times, until the action feels familiar and easy.
6. Practice using the skid steer hydraulic system:
   A. Raise and lower the lift arms.
   B. Tip the bucket forward and roll it back.
7. Park the skid steer and then lock its brakes. With adult supervision and while wearing a blindfold, raise and lower the lift (boom) arms and tilt and roll the bucket as you are instructed by your leader or supervisor. You must be able to use the proper controls to operate the skid steer without errors.
8. With blindfold off, practice scooping sand or sawdust or mulch from a pile while a supervisor observes. Pay attention to how much you scoop into the load bucket, and how heavy it is to lift. With the bucket down low, slowly move the loaded material to a nearby location and dump it.

Apply: Summarize some ways to stay safe while using a skid steer loader. You could do this via a group discussion, a poster, a short video presentation, or a live presentation.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 4.4

ATVs and Utility Vehicles

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Intermediate through advanced

Ages: 12-18 (8-11 if an appropriately sized ATV is available)

Learner Outcomes: Learn to safely use ATVs and utility vehicles for work and recreation.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4 and can safely use ATVs and utility vehicles for work and recreation.

Life Skills: Risk assessment, reading, analysis, public speaking, video production, ATV operation, ATV safety

Tags: ATV, all-terrain vehicle

Time Needed: 1 hour, depending on the experience of students and the number of ATVs and instructors available

Materials List:

- at least two ATVs, sized appropriately from the chart below for the ages of participating youth, with operator's manuals
- cones or other markers for ATV driving course
- one full face shield helmet or helmet and goggles per ATV available
- computers with internet connectivity
- video camera or cellphone (optional, for "Apply")
- poster board and markers (optional, for "Apply")
- pens/pencils
- copies of Let's Do It

Space: Classroom or other indoor space (parts 1–3 and "Apply")

Farm field (part 4)

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Advise all the youth to wear sturdy, over-the-ankle shoes suitable for ATV driving. Scout out an open, flat area for beginning ATV driving.

Variation: For part 3, if your speaker gives permission, video record the story and add a summary at the end to answer the questions in part 3. Share the video on YouTube or elsewhere.

Introduction: Review the All-Terrain Vehicles section of Chapter 4.

Opening Questions: Have you driven an ATV for work or recreation? Are you familiar with tasks on the farm(s) using ATVs? Do you know or have you heard of anyone who's had an accident involving an ATV? If so, summarize what happened and how the accident might have been prevented.

ACTIVITY 4.4

ATVs and Utility Vehicles

LET'S DO IT!

1. Visit the John Deere website, deere.com, or the Bobcat website, bobcat.com, to learn about ATV specifications for weight, payload, and engine size. Also consider the age recommendations below to determine which size ATV is right for you and the jobs you expect to do.
2. Search the internet for articles about ATV and utility vehicle injuries and deaths, preferably local to you. Create a poster presentation to display for your club, a county fair, a local safety event, or a local ATV or utility vehicle dealership.

Manufacturers' age and size recommendations for ATV operation	
Age of operator	**ATV engine size**
Under 6 years	Not recommended
6–11 years	Under 70 cc
12–15 years	70–90 cc
16 years and older	Over 90 cc

3. Ask a person injured in an ATV incident to tell the story to the group. Discuss the situation after the story. What dangers does the story point out? How can they be avoided?

4. Review the operator's manual for the ATV you will practice driving, especially the information on ground motion controls. Practice starting the ATV, putting it in gear, and moving it slowly in a figure-eight pattern. Once you are comfortable moving forward smoothly, try steering the ATV in reverse, first in a straight line, and then slowly in a figure eight.

Apply: Summarize some ways to stay safe while using an ATV. You could do this via a group discussion, a poster, a short video presentation, or a live presentation.

Learn More: To see another set of suggested ATV safety activities, visit **progressiveag.org**.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 4.5

Telehandlers

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to use a telehandler safely and understand the concepts of machine and load stability.

Education Standard(s): **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–5, can safely use a telehandler, and understands the concepts of machine and load stability.

Life Skills: Risk assessment, analysis, public speaking, video production, telehandler operation, telehandler safety

Tags: Telehandler

Time Needed: 1.5 hours, depending on the experience of students and the number of telehandlers and instructors available

Materials List:

- telehandler, with operator's manual
- material for load-moving practice (preferably a small- to medium-size rectangular hay bale)
- safety glasses
- pens/pencils
- copies of Let's Do It
- computers with internet connectivity (optional, for "Apply")
- video camera or cellphone (optional, for "Apply")
- poster board and markers (optional, for "Apply")

Space: Farm field and classroom or other indoor space

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Scout out an open, flat area for beginning telehandler practice.

Introduction: Review the Telehandlers section of Chapter 4.

Opening Questions: Have you seen a telehandler in use? Have you driven one? Are you familiar with tasks that use telehandlers on the farm(s)? Can you name a few? Summarize some hazards of using a telehandler.

LET'S DO IT!

ACTIVITY 4.5

Telehandlers

1. If you have never operated a telehandler, visit an equipment dealership and ask to sit in the telehandler's cab to observe the controls, and identify where the controls are located. This may be done with your employer's guidance instead, or with the telehandler available for practice today.
2. Use the operator's manual for the telehandler you will operate to study the controls and instrument gauges as you sit in the operator's position.
3. Practice starting and stopping the telehandler, raising the boom, extending and retracting the boom, leveling the frame of the telehandler while sitting with the parking brake set, and/or lowering and raising the outriggers.
4. Practice driving the telehandler with no load. Use the 2-wheel, 4-wheel, and crab-drive functions.
5. Practice picking up and lifting a load, extending the loaded boom, and lowering the load.

Apply: Summarize some ways to stay safe while using a telehandler. You could do this via a group discussion, a poster, a short video presentation, or a live presentation.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 4.6

Tractor Front-End Loaders

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to safely use a tractor-mounted, front-end loader, and understand how the center of gravity of a farm tractor changes as the front-end loader is used.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4, and can safely use a tractor-mounted, front-end loader, and understand how the center of gravity of a farm tractor changes as the front-end loader is used.

Life Skills: Risk assessment, analysis, tractor front-end loader operation, tractor front-end loader safety, public speaking

Tags: Tractor front-end loader

Time Needed: 1.5 hours, depending on the experience of students and the number of tractors and instructors available

Materials List:

- tractor-mounted front-end loader, with operator's manual, preferably medium sized (~35-50 HP), wide front-end wheels, an ROPS, and a seat belt
- material for load-moving practice (preferably sand, sawdust, or mulch)
- safety glasses
- dump truck or other large container or four cardboard boxes and four pieces of PVC pipe
- pens/pencils
- copies of Let's Do It

Space: Farm field and classroom or other indoor space

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Scout out an open, flat area for beginning practice with a tractor front-end loader. Set up a simple construction of cardboard boxes and PVC pipe to create a target height for practice how to approach and retreat with a loaded bucket.

Introduction: Review the Tractor Front-End Loader section of Chapter 4.

Opening Questions: Have you seen a tractor front-end loader in use? Have you driven one? Can you name some tasks on the farm that use tractor front-end loaders? Summarize some hazards of using a tractor front-end loader.

LET'S DO IT!

ACTIVITY 4.6

Tractor Front-End Loaders

1. Answer the following question:

   A. What happens to a tractor's center of gravity when you raise the front-end loader?

   ____

   B. Why should the front-end loader be lowered to the ground before you leave the operator's seat?

   ____

   C. Describe a situation in which load rollback can occur.

   ____

2. Become familiar with front-end loader controls by practicing the raising and lowering of the front-end loader and then rolling the bucket or attachment forward and back. Do this until you are comfortable with what each control movement does as you use it.

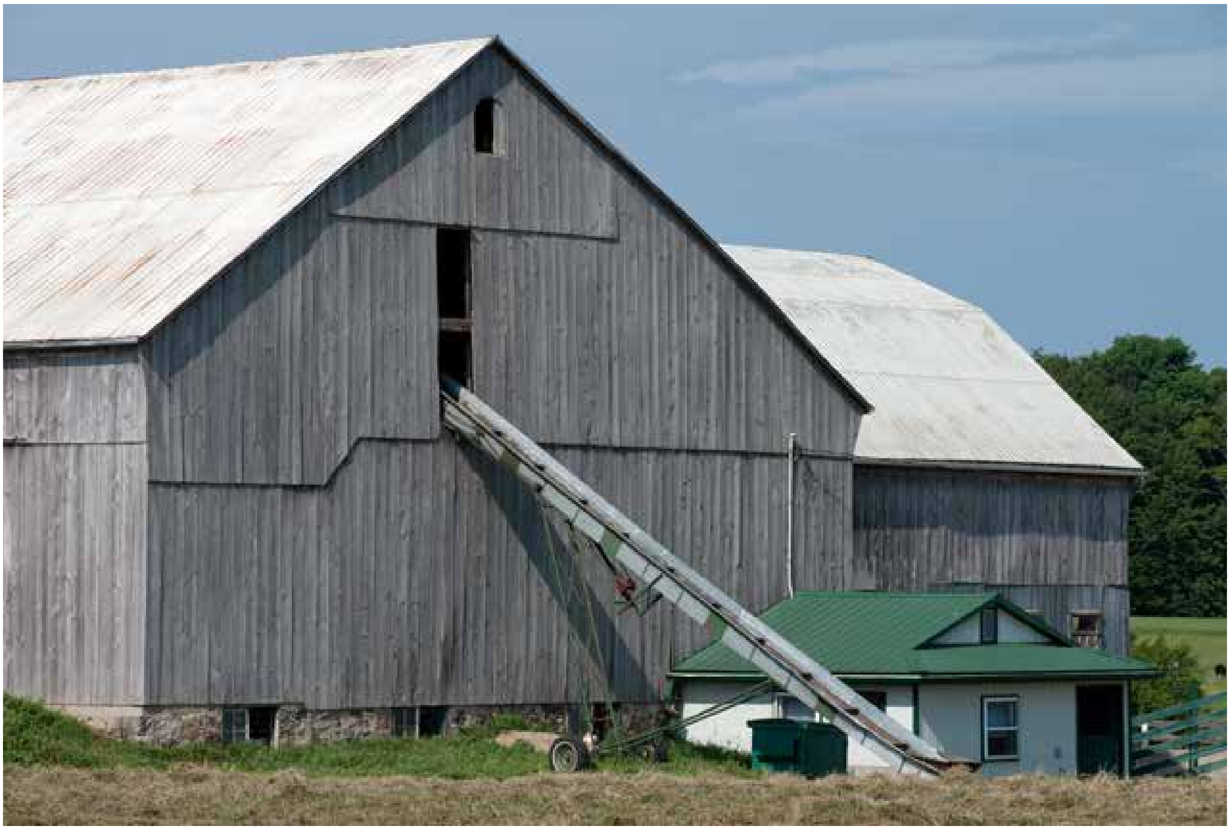
3. Using a pile of sand, sawdust, or mulch, practice scooping from the pile while a supervisor observes how you approach the pile of material. Pay attention to how much you scoop into the bucket, and how heavy it is to lift. With the bucket down low, slowly move the loaded material to a nearby location and dump it. Request that a supervisor observe your initial efforts.

4. When you have mastered parts 2 and 3 above, with a supervisor, repeat the activity, but place the load into a dump truck or other container by approaching the dump truck or container slowly, raising the bucket fully, adjusting the final approach, and then dumping the load carefully without damage to the truck or container

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 4.7

Augers and Elevators



LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn to safely use an auger and an elevator, and to identify hazards related to their use to remain safe and avoid entanglement or electrocution.

Education Standard(s): **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

FPP.01. Develop and implement procedures to ensure safety, sanitation, and quality in food product and processing facilities.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–3, can safely use an auger and an elevator, and can identify hazards related to their use to stay safe and avoid entanglement or electrocution.

Life Skills: Risk assessment, analysis, math, auger operation, auger safety, elevator operation, elevator safety

Tags: Auger, elevator

Time Needed: 1 hour, depending on the experience of students and the number of tractors and instructors available

Materials List:

- tractor to operate auger
- auger, with operator's manual
- material for auger practice (small grains such as shelled corn, wheat, oats, or silage)
- elevator, with operator's manual
- material for elevator practice (preferably rectangular hay or straw bales)
- pens/pencils
- camera, computer, and printer (for part 3)
- copies of Let's Do It
- paper

Space: Barn, work shed, or farmyard and classroom or other indoor space

Suggested Group Size: Maximum of five people per instructor

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State Universitys.

Experience:

Before the Activity: Scout out an open, flat area for beginning practice with an auger and an elevator.

Introduction: Review the Augers and Elevators section of Chapter 4.

Opening Questions: Have you seen an auger or an elevator in use? Have you used either? Can you name some tasks on the farm that use augers and elevators? Summarize some of the potential hazards when using an auger and an elevator.

LET'S DO IT!

ACTIVITY 4.7

Augers and Elevators Loaders

1. Using the internet, search for agricultural injuries and/or fatalities involving an auger or elevator. Analyze three of these incidents to determine whether the incidents had anything in common. Compare the age of the victim, machine condition, time of year, and any other factor in your analysis. A good source of information is found at **extension.psu.edu/business-and-operations/farm-safety** (type "farm injury summary" in the search bar). Another good source is at **aginjurynews.org** (free registration required).
2. Solve this math problem. If a 10-inch auger can move 65 bushels of grain per minute, how many bushels of grain will a 7.5-inch auger move in one minute? Show your work in this ratio calculation. First, identify the known ratio and the unknown ratio. Then set up the proportion. Finally, cross-multiply and solve.
3. Conduct a safety check on the augers and elevators on the farm with which you are most familiar (with their permission and supervision). Using the safety recommendations learned in the Augers and Elevators section of Chapter 4, develop a report that could be given to the owner or presented to the group. Include pictures and identify any safety concerns.
4. With qualified adult supervision, practice using the auger to safely move material.
5. With qualified adult supervision, practice using the elevator to safely move material.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 4.8

Silage Defacers, Silage Bagging, and Bale Wrapping Equipment

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Understand silage removal procedures. Safely use silage defacing, silage-bagging, and bale-wrapping equipment.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–4; understands silage removal procedures; and safely uses silage-defacing, silage-bagging, and bale-wrapping equipment.

Life Skills: Risk assessment, analysis, math, public speaking, silage defacer safety, silage bagger safety, bale wrapper safety

Tags: Silage defacer, silage bagger, bale wrapper

Time Needed: 1 hour

Materials List:

- computer(s) with internet connection
- pens/pencils/markers
- copies of Let's Do It!
- paper

Space: Classroom or other indoor space

Suggested Group Size: Five to 10 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Introduction: Review the Silage Defacers, Silage-Bagging, and Bale-Wrapping Equipment sections of Chapter 4.

Opening Questions: Have you seen a silage defacer or silage bagger or wrapper in use? Have you helped use any of these? If you know anyone who's had an incident with any of this equipment, share with the group what happened.

LET'S DO IT!

ACTIVITY 4.8

Silage Defacers, Silage Bagging, and Bale Wrapping Equipment

1. Search the internet for videos about silage defacer equipment. Watch a few to see how the equipment is operated and then make a list of the hazards you can identify.

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2. After listing the hazards involved in using a silage defacer, draw safety symbols that could help a person understand the hazards involved in using a silage defacer.

3. Attend an agricultural exposition in your state and watch a field demonstration of how silage-bagging and/or bale-wrapping equipment operates. Alternatively, watch a few videos online to see how this equipment is operated and then make a list of the hazards for each.

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 ____

4. Assume that a silage bag has a radius of 4 feet and is 200 feet long. Calculate the volume of this "tube" in cubic feet. If a cubic foot of corn silage weighs 35 pounds, how many tons of silage are being stored?

 Use this formula: Volume = 3.14 x radius^2 x length

 Follow the order of operations in math. Remember, there are 2,000 pounds in a ton.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Chapter 5
Occupational and Environmental Hazards

Please see Note to Leaders at the front of this book for some important safety and logistics considerations.

Farming takes place outside, typically in unheated buildings, in challenging conditions, with potentially dangerous substances, in all types of weather. This chapter discusses hazards on the farm, including severe weather, respiratory risks, noise, chemicals, fire, wildlife, insects, and farm ponds.

Warm Weather Hazards

Introduction

Farm work does not stop for summer heat or winter cold. Crops must be harvested, livestock must be tended, and every daily routine must be completed. Safe work practices still must be observed in any kind of weather.

This section discusses how to recognize severe weather and the effects of such weather on farmworkers.

Crop production activities begin with the arrival of the summer season. This is the time of year to expect higher temperatures, higher humidity, thunderstorms, lightning, and tornadoes. Attention to safe work practices may not permit full attention to weather hazards. Each of the following hazards is discussed in greater depth below.

High temperatures—Exposure to high summer temperatures can cause illness. Heat cramps, heat exhaustion, and heat stroke are serious problems.

High humidity—Excessive humidity means moisture evaporation slows down. Perspiration helps to cool the body by evaporation. In high humidity, the body continues to lose moisture, but the cooling effect is not felt.

Lightning—Cold fronts bring cooler air into contact with warm air masses. Severe thunderstorms (figure 5.1) can occur. In an average year, about 49 people are killed by lightning in the United States.

Tornadoes—These typically small but violent storms can pack up to 250-mph wind gusts. They usually follow dark skies with clouds that look like a wall and wind that sounds like an approaching freight train. Tornadoes kill people and cause millions of dollars in property damage every year.

Severe weather can occur at any time of year.

Figure 5.1 Summertime forecasts of extreme weather must be heeded. Attention to machine safety is a top priority, but changing weather conditions must be observed as well. Credit: Pixabay CC0.

Health Risks from the Sun

Farmers are strong and hearty people. But farmers still must pay attention to the dangers posed by farm work during the summer season.

Health risks increase from overexposure to the sun and heat. These include:

- sunburn/skin cancer
- eye damage from ultraviolet (UV) light
- overheating/dehydration
- overheating/heat stoke

Sunburn/Skin Cancer

Farmworkers must spend a great deal of time working in the sun. Overexposure to the sun leads to sunburn, an actual burning of skin cells. Prolonged exposure to the sun over time is the most common cause of skin cancer. As the number of exposures to the sun increases, so does the chance of developing skin cancer.

Preventing Sunburn and Skin Cancer

Protect the skin from the harmful effects of the sun by dressing properly (figure 5.2) in long sleeves, long pants, a bandanna, and a broad-brimmed hat. Use sunscreen with at least SPF30 rating for exposed areas. Follow application instructions on the container.

The American Cancer Society provides information about skin cancer.

Note: One sunburn experience will not cause cancer, but continuing exposure to the sun from working outdoors can increase the risk of skin cancer.

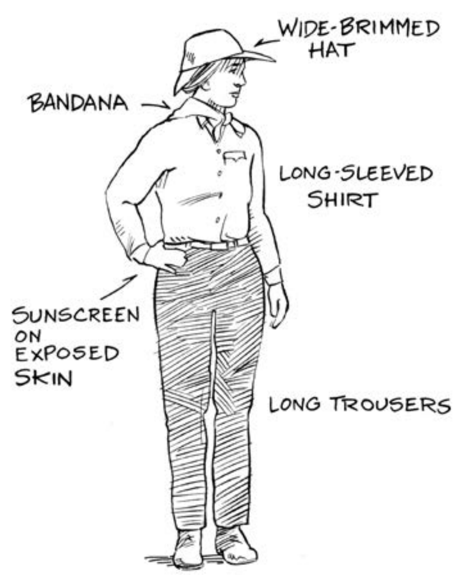

Figure 5.2 This drawing shows the recommended clothing and skin care precautions for summer sun exposure. Credit: J. Mathison.

A worker suffering from sunburn is not a productive worker.

Eye Damage from Ultraviolet (UV) Light

The eye controls the amount of light used to focus an image on the optic nerve. Any damage limits the ability of the eye to function properly, and some vision may be lost.

The sun produces different kinds of light:

- ultraviolet (UV) invisible radiation
- bright or intense light
- blue light (a visible light)

The bright sun can damage the eye through the effects of UV radiation. This damage is called keratitis, an inflammation of the cornea of the eye. Sun-induced cataracts (a clouding of the lens of the eye) have been reported.

Blue light is visible light from the blue portion of the color spectrum. The intense glare from snow or water contains blue light. This intense light prevents people from focusing clearly. Intense glare leads to eye strain and fatigue. Prolonged exposure to blue light is believed to age the retina in the eye, which increases the risk of blindness.

Protecting the Eyes

Protect the eyes from the harmful effects of the sun with the correct type of sunglasses. Sunglasses that block 99–100% of both UVA and UVB rays are best. The word “protection” on the packaging does not guarantee the sunglasses will block or absorb UV rays.

Blue light blockers appear as yellow-tinted lenses in our glasses. These lenses alter the blue and green colors to reduce glare without making the world appear darker. When working in bright, glaring conditions, these sunglasses can be helpful.

Note: The price tag of sunglasses is not a measure of their blockage or absorptive value.

Sunglasses are not to make people look cool. Sunglasses protect the eyes.

Dehydration

Sweating or perspiring is normal for a hot summer day. When the heat of the day is coupled with strenuous work, perspiration losses may equal or exceed water intake. **The body can lose as much as three gallons of water in a day.** Water serves as a coolant to our bodies.

When working on a hot day, a person can become fatigued or tired. Excessive sweating removes elements such as sodium, potassium, and chloride from our bodies. Water will not replenish minerals lost through perspiration. Sports drinks contain minerals that replenish our systems. Sodas do not replenish our nutrient needs. To replenish mineral needs, eat healthy foods before going to work and drink plenty of liquids during work.

Overheating

Exposure to summer heat and humidity can cause serious illness. Health risks from heat occur when the body cannot cool down by sweating or replenish the fluids and minerals lost through perspiration. According to the CDC, an average of 175 people die each year in the U.S. from the effects of summer heat.

Health problems from heat can include:

- **Heat rash**—When sweat does not evaporate from the skin, the pores can become clogged. A rash develops. Clothing made of synthetic fibers, such as polyester and polypropylene, and natural fibers, such as merino wool, can help to wick the moisture away from the skin. Use corn starch to treat the rash.
- **Heat syncope**—Extreme heat can cause fainting. Help the victim to lie down in a cool spot, and elevate their legs to improve circulation. Let them rest there. Give the victim water, clear juice, or a sports drink.

- **Heat cramps**—Leg and stomach cramps are caused by loss of body fluids due to sweating. Regularly drink cool water and/or a sports drink with minerals to cool the body. Massage the cramps.
- **Heat exhaustion**—Loss of body fluids and salts from sweating and decreased blood flow to the brain can cause heat exhaustion. Symptoms include cool, moist, pale or flushed skin, headache, nausea, dizziness, weakness, and exhaustion. Go to a cool place, lie down with feet elevated, and drink plenty of cool fluids. Medical help should be summoned.
- **Heat stroke**—Heat stroke is a medical emergency. The body's systems are failing. Symptoms include red, hot, and dry skin (perspiration has stopped); changes in consciousness; convulsions; delirium; rapid, weak pulse; and rapid, shallow breathing. The victim may become chilled. Some victims exhibit anger. **Heat stroke can be fatal if not treated immediately.**

Treating Heat Stroke

Heat stroke is a medical emergency. Follow these treatment procedures immediately:

- Call for medical help at once.
- Remove the victim's outer clothing.
- Immerse the person in cold water. If no pool, bathtub, or natural waterway is available, sponge the person's body with water until help arrives.
- Do not give the person anything to drink.

Heat stroke is an emergency requiring immediate medical care.

Preventing Heat Illness

Follow these guidelines to prevent heat illness:

1. Drink water (figure 5.3) approximately every 15 minutes. Do not wait to be thirsty.
2. Avoid caffeinated and alcoholic drinks.
3. Wear appropriate summer clothing that fits loosely and reflects the sunlight.
4. Perform the most strenuous jobs during the coolest part of the day.
5. Take periodic breaks in the shade.
6. Adjust gradually to the heat.

Figure 5.3 Water is a substance we must have. It cools the body, carries nutrients, and flushes waste from the body. Credit: Pixabay CC0.

Effects of Humidity on Sweating

Evaporation rates are reduced with excessive humidity. Evaporation of water and sweat has a cooling effect. Higher humidity limits evaporation and makes air temperatures feel higher. A heat index chart shows the "apparent temperature" (figure 5.4) by accounting for air temperature and humidity.

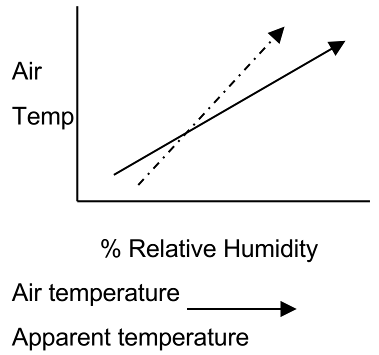

Figure 5.4 As humidity levels increase with rising temperatures, the apparent temperature (heat index) may feel higher than the reported temperature. Credit: PSU Ag Safety.

Lightning

Farm work does not stop because the weather forecast calls for thunderstorms, rain, lightning strikes (figure 5.5), or even a threat of tornadoes. Work may be interrupted by these events when they happen, but the work is not canceled until the weather event occurs.

Note: Field work puts stress on everyone, especially if the weather report predicts stormy conditions will interfere with planned (and necessary) work. The first priority is safe equipment operation. Knowledge of weather patterns and how they change can improve safe work habits.

Sudden rainstorms are often preceded by violent lightning storms. Lightning is caused by a buildup of static electricity in the air.

Figure 5.5 Lightning strikes can be fatal. Take shelter indoors, if possible. Do not seek shelter beneath trees or near utility lines. Credit: Pixabay CC0.

Lightning fatalities rank second to floods in weather-related deaths. Lightning energy as high as 100 million volts and as much as 50,000 degrees F is released within a half-second Lifelong disability and death can result from exposure to the extreme levels of electricity and temperature.

Lightning Myths and Truths

Myth 1: Lightning does not strike the same place more than once.

Truth: Lightning can strike in the same place many times.

Myth 2: Lightning occurs only under stormy skies.

Truth: Lightning can strike 10 miles away from a storm.

Precautions to Take if Severe Thunderstorms Are Predicted

- Check the weather forecast before starting work.
- Observe threatening clouds and increasing winds.
- Use the “30-30 rule.” If the time delay between seeing the flash of lightning and hearing the bang of thunder is less than 30 seconds, move toward shelter. Lightning can strike 30 minutes before or after a visible storm.
- In an open field, seek low spots for shelter.
- Seek shelter at a location away from hilltops, trees, or utility lines.
- Use closed buildings for shelter, if possible. Do not use items connected to plumbing or house wiring.
- Vehicles and tractors with cabs can be used for shelter.

Hurrying to beat a storm during harvest increases the risk of injury.

High Winds and Tornadoes

A tornado (figure 5.6) is a violently rotating column of air extending from a thunderstorm to the ground. Eastward-moving cold fronts colliding with warm, moist air form ideal conditions for high winds and tornadoes to develop, sometimes rapidly.

Tornadoes accompany thunderstorms. Watch for these indicators of tornado potential:

- dark, often greenish sky
- large hail
- a cloud that looks like a wall
- a loud roaring sound

Be prepared to respond immediately to these weather signals.

Remember the following in the event of a tornado:

- Understand the local radio and siren warnings used for impending weather emergencies.
- If a **tornado watch** is issued, remain alert to the threat of storms.
- If a **tornado warning** is issued, a tornado has been sighted or has appeared on weather radar. Move to safe shelter immediately.
- Do not try to outrun a tornado. The speed and direction of a tornado can be deceiving and changing.
- If caught outdoors in high winds or a tornado, seek a ditch or low spot for protection. Lie face down, and place your hands over your head.
- When sheltering in a building, go to the basement or to an inner room. Stay away from outside walls, which may collapse, and stay away from windows, which may shatter.

Figure 5.6 Tornadoes and high winds lead to destruction and falling debris from trees, buildings, and utility wires. These storms can carry winds of up to 250 mph. Credit: Pixabay CC0.

Tornado Myths and Truths

Myth 1: Tornadoes cause buildings to explode.

Truth: Violent winds and debris smashing into the building cause most of the structural damage.

Myth 2: The windows of the house should be opened to equalize pressure and minimize damage.

Truth: Opening the windows only opens the building to the damaging winds. Go to a safe place instead.

With early-warning systems in place throughout the United States, tornado deaths have been reduced greatly. Know what the changing weather means for outdoor safety.

National Oceanic and Atmospheric Administration (NOAA) Warnings

The National Oceanic and Atmospheric Administration (NOAA) conducts weather and environmental observations (figure 5.7) around the world. NOAA information is used by National Weather Service forecasters to report weather patterns and events. NOAA satellite data benefits many groups. Aviation, maritime, and farm groups need up-to-the-minute weather information to ensure safety and economic success.

Special NOAA weather radios continuously broadcast updated weather warnings and forecasts. The radio's average range is 40 miles, depending upon topography. Some NOAA radios automatically sound a tone when a watch or warning is issued nearby. It's a good idea to keep a NOAA weather radio close by on days with the potential for severe thunderstorms.

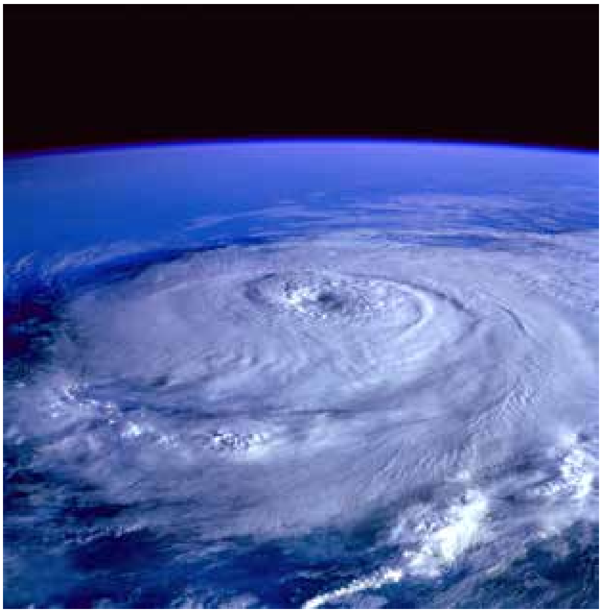

Figure 5.7 NOAA and the National Weather Service track weather developments to give advance notice of weather problems to airlines, maritime operators, and farmers. Credit: Pixabay CC0.

Rain and Rainstorms

Regular rainfall is necessary for crop growth. Periods of drought reduce yields and cause anxiety for farmers. Excessive rainfall (figure 5.8) delays planting and harvest, which also causes frustration. Rain is necessary for success, but too much rain and rainstorms affect farm safety.

Here are a few effects of weather:

- Excessive rain causes reduced traction. Tractor steps may be mud-covered. Fields may be slippery. Tractors can become stuck.
- Excessive rain causes flooding. Crops can be damaged when soils become saturated.
- Saturated soils cannot hold more water. Flash flooding can occur. High water can sweep people and vehicles away.
- Rainy periods delay crop operations, resulting in potential yield and quality loss.
- Long periods of weather extremes frustrate farmers. Unsafe acts can result as producers attempt to hurry to complete the work.

Safety must remain top priority in farming despite bad weather conditions.

Clouds as Signals of Weather

Figure 5.8 Excessive rainfall delays crop operations, reduces traction, and builds frustration. Credit: Pixabay CC0.

Clouds can help predict weather. Figure 5.9 shows cumulus clouds. These heaped or lumpy clouds indicate a period of fair weather. Figure 5.10 shows stratus, layered clouds. They are full of ice crystals. These layered clouds can also form fog and mist. Figure 5.11 shows a cumulonimbus cloud. These towering clouds have an anvil shape at the top. They forecast rain, hail, or storms. Try observing clouds and making weather predictions.

Figure 5.9 Cumulus clouds. Credit: J. Mathison.

Figure 5.10 Stratus clouds. Credit: J. Mathison.

Figure 5.11 Cumulonimbus clouds. Credit: Pixabay CC0.

Individuals are responsible for their own safety and have the right to take appropriate action when threatened by severe weather. Nobody can force someone else to work in a dangerous situation.

Cold Weather Hazards

When the snow piles up and the roads ice over, much farm work continues. Safe work habits must be practiced under all weather conditions (figure 5.12). Frostbite, hypothermia, and decreased traction pose hazards farmworkers must understand.

While people may become accustomed to working in the cold, exposure to low temperatures and wintry wind can be dangerous. For example, slippery conditions affect the ability to safely handle equipment and livestock.

Figure 5.12 Winter weather brings a different set of rules for work. Attention to farm chores may cause the worker to forget that the air is icy cold and that the skin can freeze. Credit: Pixabay CC0.

Frostbite

Frostbite occurs when body tissue becomes frozen. Numbness in body parts signal the outdoor worker the appendage is too cold and in danger of further damage.

To prevent frostbite, workers must pay attention to how their body is reacting to the low temperatures. Covered skin is at risk for frostbite as well as exposed skin.

If a person develops frostbite, seek shelter and use warming towels or lukewarm water to warm the skin. Never use hot water. It can burn the skin. Severe cases of frostbite require immediate emergency medical treatment.

Frostbite destroys body tissue.

Hypothermia

Hypothermia occurs as the body's temperature drops below 96 degrees Fahrenheit. Exposure to severe cold causes this condition. Extreme cold can produce weakness, drowsiness, or confusion, which can lead to further exposure and eventually death.

To prevent hypothermia, dress in layers (figure 5.13) to help trap air between the clothing. Air has an insulation value. Wear a head covering as well. Proper winter dress should keep workers warm, not hot, and also fit snugly for safe work around equipment and livestock.

Seek immediate medical treatment and gradual warming for a hypothermia victim.

High winter winds coupled with low temperatures may result in a wind chill advisory.

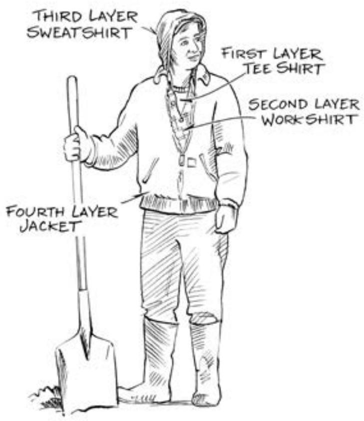

Figure 5.13 Layers of clothing offer the best cold weather protection. If the day's weather warms, outer layers can be removed. Synthetic fibers wick away the moisture of perspiration, while cotton materials absorb and hold moisture. Moisture next to the skin promotes chilling. Credit: J. Mathison.

Loss of Traction

Winter weather brings icy and muddy conditions. Footing is more difficult for people and livestock. Tractors may slip and slide. Livestock can slip, fall, and be injured. Animals being moved on slippery surfaces can slide into workers. Consider the following list of extra precautions:

- Footwear must have treads to provide traction (figure 5.14). Consider wearing traction chains with work shoes or boots in icy conditions.
- Use traction chains on tractor tires under extremely icy conditions.
- Operate the tractor carefully and more slowly than when weather conditions are dry.
- Recognize vehicles on public roadways may need greater distances to slow down as they approach farm equipment sharing the road.
- Move livestock slowly to prevent animals from falling or sliding into workers.

Winter activities require slower, more deliberate movements to prevent injury.

REMEMBER: Loss of traction means loss of control.

Figure 5.14 Be extra careful while mounting the tractor steps in icy conditions. Credit: Pixabay CC0.

Respiratory Hazards

The daily activities of farming generate dust and dirt. Working with crops, livestock, and equipment creates more dust and dirt. Farmworkers are placed in conditions perfect for the growth of microorganisms, such as fungi and molds. Workers are often exposed to hazardous gases and vapors in the farm shop.

Continual exposure to breathing hazards creates long-term health problems. Farmworkers can suffer from breathing difficulties, such as asthma, "farmer's lung," organic dust toxicity syndrome (ODTS), and silo-filler's disease.

Coal miners can get "black lung" from breathing coal dust. Farmers can get "farmer's lung."

Dusts, Mists, and Fumes

Particulates are airborne particles of material. Dusts (figure 5.15), mists, and fumes contain particles measured in microns. A micron is 1⁄25,400 of an inch. A particle 50 microns in size is typically visible to the naked eye. Particle sizes over 5 microns are heavy enough to settle quickly without posing a respiratory hazard. Smaller materials are the major concern to lung health.

Dusts—Dusts include the solid particles (0.1–25 microns in size) created by handling, crushing, grinding, and moving materials such as rock, metal, wood, and crops.

Crop production exposes the worker to dust particles from the crop, spores from microorganisms growing on the crop, and the fine, airborne particles of soil stirred by field work. Fine particles can be inhaled into the lungs (respirable dust). As plant materials break down, molds and fungi grow, and those can also be inhaled.

Livestock production exposes the worker to dirt, dust, mites, fungi, and the dry scaly skin found on or around the animal or bird or in its housing area. Prescribed antibiotics added to livestock feeds can also pose a respiratory hazard.

Mists—Mists are liquid droplets suspended in the air. They represent another respiratory hazard. Paint sprays and cutting oil become airborne breathing hazards.

Fumes—Materials that become airborne during welding (such as metal, welding rod, and flux) are an example of fumes.

Respirators should be worn if dust is visible in the air when a concrete shop or barn floor is in the air indicates the presence of invisible particles also. Those can enter lungs and cause problems.

Figure 5.15 Dust from agricultural work can lead to eye and lung irritation. A filter mask such as this provides respiratory protection. Credit: J. Mathison.

Welding

Ventilation is necessary during all welding processes. Galvanized metal emits zinc fumes during welding. These fumes can be fatal when inhaled. Welding gases such as acetylene can be explosive in high concentrations. The arcing of a light switch can cause acetylene vapors to explode.

Engines

Engines produce deadly carbon monoxide gas. This colorless, odorless gas can asphyxiate the worker who operates an engine in an enclosed area. Do not operate an internal combustion engine inside a closed building.

Gases and Vapors

Chemical reactions of materials with the air produce gases and vapors. Gases are released from chemical reactions, such as manure decomposition, silage fermentation, and the exhausts of internal combustion engines. These gases exist during normal temperatures of the reaction.

Vapors are gases from substances that are normally solid or liquid. Evaporation from liquids, such as pesticides, paints, adhesives, and solvents, produces vapors, which are airborne breathing hazards.

Solvents and Paint Thinners

Vapors from paint thinners or solvents are released into the air and can be explosive. Paint thinners also produce symptoms of nausea when inhaled. Skin damage is possible. Read the labels on solvents and thinners to learn about ventilation requirements.

Manure Gases

Manure breaks down chemically when held in storage pits. Hydrogen sulfide, carbon dioxide, ammonia, and methane gases are produced in the manure. These gases intensify in concentration and are trapped in the manure. They use and displace oxygen so the oxygen level of the storage pit or tank becomes too low to support life.

To move the manure from storage to field application, the manure must be agitated and pumped to a spreader unit. During agitation and pumping the gases are released into the air.

With equipment breakdowns, unsuspecting farmworkers, coworkers, and family members have entered the unventilated, low-oxygen-level, confined areas and have been killed by suffocation. Multiple fatalities have occurred during rescue attempts. Stay out of manure storage facilities!

Manure gases can cause asphyxiation, eye and nose irritation, or can explode due to methane buildup.

Silo Gases

The silage fermentation process produces deadly nitrogen dioxide gas. This yellow-brown gas is heavier than air and settles to a low point in the silo or feed room. Workers entering unventilated silos can be overcome by this gas and may suffer permanent lung damage. A few victims perish from silo-filler's disease.

Farm Shop Gases

The farm shop exposes workers to respiratory hazards during jobs such as welding, painting, and engine repair (figure 5.16). Ventilation is needed for each of these tasks.

Workers must know how to activate ventilation fans in the farm shop.

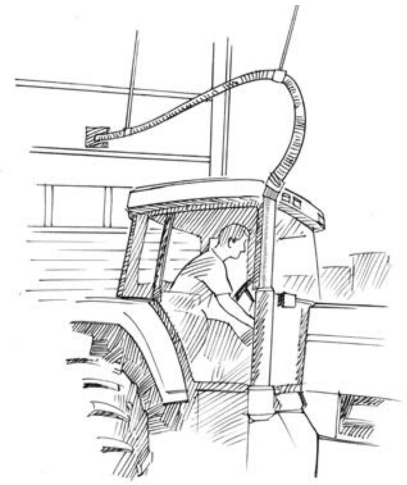

Figure 5.16 Internal combustion engines produce carbon monoxide in exhaust. This colorless, odorless gas can asphyxiate or suffocate a person working on the engine in an enclosed area. Be sure to ventilate the exhaust gases to the outside of the building or work with plenty of air flow into the building. Credit: J. Mathison.

Oxygen-Deficient Atmospheres

The air we breathe normally contains about 21% oxygen.

Some agricultural storage areas are oxygen-free by design or by the chemical reaction going on inside of them.

- Sealed silos (figure 5.17) are kept free of oxygen to keep certain bacteria from spoiling the silage.
- Controlled atmosphere (CA) storages of fruits and vegetables have lower oxygen levels to maintain food quality and storage times.
- Manure storage areas (figure 5.18), when enclosed or covered, become oxygen-deficient as manure decomposition depletes the oxygen supply.

Figure 5.17 Silo gas can leave a person unconscious or dead. It is difficult to rescue a victim from inside of a farm silo. Credit: Mark Ellis, Flickr https://creativecommons.org/licenses/by-nc-sa/2.0/.

Figure 5.18 Safety signs warn us of immediate danger. This sign tells us that respiratory protection is required. What other safety practices does this warning sign recommend? Credit: J. Mathison.

Lung Diseases Related to Dust

Inhalation of dusts, mists, fumes, vapors, and gases causes irritation to the respiratory system. Repeated, prolonged exposure can cause more severe problems. Two of the problems are:

Farmer's lung—Farmer's lung is an allergic reaction caused by inhaling dust particles from moldy hay, straw, or grain. When the lungs cannot remove the material, an allergy can develop. Repeated exposure further increases lung tissue damage and allergic reaction. Symptoms are similar to those of pneumonia. A person with farmer's lung is often driven from the farm because their tolerance to any organic dust is so low.

Organic dust toxicity syndrome (ODTS)—ODTS is caused by a reaction to the inhalation of molds from the dust of spoiling grain and forage. Symptoms include cough, fever, chills, body aches, and fatigue. Symptoms can last up to seven days. Different from farmer's lung, ODTS is not an allergic reaction and normally does not cause permanent lung damage.

Asthma

Asthma is a disease of the respiratory system. Many people with asthma use an inhalant (medicine in an aerosol tube) to provide breathing relief. National statistics show an increase in the number of people suffering from asthma. Doctors don't fully understand how people develop asthma.

In a person with asthma, the small air tubes of the lungs tend to make more mucous than normal. The air tubes tend to swell, and the muscles around the air tubes tighten when an asthma attack occurs.

Asthma can be triggered by several factors:

- allergies
- infection (colds and bronchitis)
- weather changes
- smoke

- physical exercise
- air pollutants

Exposure to dusts, mists, fumes, vapors, and gases irritates the lungs and can cause an asthma attack. All of these irritants can be found in agriculture. Weather changes can lead to colds and bronchitis. Hot, humid weather, as well as winter cold, are factors in asthma. Smoking cigarettes or standing in the smoke of a fire are also irritants to the lungs. Sports activities and physical work can trigger an asthma attack, as well.

For asthma sufferers, there are two recommendations:

1. Avoid the factors that trigger an asthma attack.
2. Follow a doctor's advice and prescription program.

Because repeated exposure to lung irritants reduces respiratory health, asthma can develop in farmers and farmworkers. Everyone who works on farms should take precautions to protect their lungs from developing asthma and other respiratory problems.

When you can't breathe, nothing else matters.® American Lung Association

Respiratory Protection

Many people believe farming means working in the clean, fresh air. But farming has many respiratory (breathing) hazards. Occasionally the air on farms can even be deadly to breathe.

This section discusses respiratory-protection devices to be used in agricultural work. Specific work hazards dictate use of certain devices to reduce lung damage. Failure to use the correct device for a particular hazard can produce the same result as using no protection at all.

Nuisance dust masks are best worn by people with no existing respiratory distress or breathing limitations for short-term exposure to light levels of non-toxic dusts, such as sweeping out a garage or shop floor. A nuisance dust mask is not a respirator. It is identified by a single strap, which typically gives a poor fit.

Don't wear contact lenses with a respirator. In any contaminated environment, contaminants can stick to contacts and cause eye damage.

Types of Respirators

There is no such thing as an all-purpose respirator. Specific respirators are used for specific contaminants. A particulate respirator (figure 5.19a) will not filter toxic chemicals. An air-supplying respirator is not needed to load hay on a wagon.

Respirators can be placed in two categories:

- air-purifying respirators
- supplied-air respirators

Air-Purifying Respirators

Air-purifying respirators are equipped with filters the user breathes through. The respirator filters may be disposable or replaceable, depending on the material to be filtered. Air-purifying respirators should be used in areas such as barn lofts with moldy hay, fields during tilling, or construction sites where fiberglass or wood dust is likely.

For most air-purifying respirators, the user must pull air through the filter with their own breathing. This type of respirator is often referred to as a negative-pressure respirator because the user must draw in oxygen (inhale) through the respiratory unit. Negative-pressure air-purifying respirators often put added stress on the user. People who suffer from respiratory problems such as asthma or lung or cardiovascular disease should check with a doctor to make sure they can wear one. There are several types of air-purifying respirators.

Filters should be replaced on a replacement-filter respirator when breathing becomes labored, the mask loses its shape or no longer fits the face snugly, or the user can taste or smell the substance being filtered. A mechanical filter for particulates is not a replacement for a chemical-cartridge filter.

Disposable particulate respirators are an approved type of respirator often referred to as dust masks, which makes it easy to confuse them with nuisance dust masks. Disposable particulate respirators protect from particulate contaminants such as dusts, mists, and sometimes fumes. The filters are made of a fibrous material that traps particles during inhalation. These respirators are useful during operations such as haying, harvesting, tilling dusty fields, applying fertilizer and lime, grinding feed, and sweeping. Both disposable and reusable particulate respirators are available.

Disposable masks should be replaced when breathing becomes labored, when the mask loses its shape and no longer seals well to the face, or if the wearer can taste or smell the substance to be avoided.

Chemical cartridge respirators (figure 5.19b) filter out low concentrations of toxic gases and vapors. An absorbent material such as activated charcoal absorbs contaminants from inhaled air. These masks can also be equipped with particulate filters. Exposure to gases or vapors and dusts or mists, such as during spray painting, requires wearing this kind of respirator.

The filtering cartridges for these respirators usually screw onto the front of the mask. The cartridges are changeable, so a reusable mask can be used for any gas or vapor contaminant, provided the right cartridge is available.

Cartridges should be replaced after eight hours of use or when "breakthrough" occurs, which is when the smell or taste of the contaminant becomes apparent, or when dizziness or irritation occurs. Make sure the cartridge brand matches the respirator brand. Manufacturers use different threads, which may prevent mismatched brands (respirators and cartridges) from sealing properly.

Supplied Air Respirators

A *powered air-purifying respirator* (PAPR) (figure 5.19c) has a motorized blower that forces air through the filtering device. A PAPR is a "positive pressure" respirator because clean air is being delivered to the breather. It makes breathing easier for the wearer, so this type of respirator may be recommended by a doctor for someone with a respiratory or cardiovascular ailment. Many PAPRs have a hard helmet and rigid visor under which the air is blown. There are also half-face and full-face models as well as models with non-rigid helmets. A person who is sweeping up moldy grain in a grain bin should wear this type of respirator.

Air-supplying respirators, such as self-contained breathing apparatus (SCBA), provide good quality air to the wearer. These respirators are used where the oxygen levels are so low they are considered immediately dangerous to life or health. These types of respirators are very expensive, require extensive training to use, and are not a practical or appropriate device for youth.

Try a different work practice to reduce breathing hazards. When at risk, use the appropriate respirator.

Selecting a Respirator

Approved respiratory protection equipment should have "NIOSH" (National Institute for Occupational Safety and Health) displayed on the device. Newer respirators will have the NIOSH approval number. Look for the designation to be sure the respirator is approved—there may be older respiratory-protection devices around the farm.

Under current standards, air-purifying masks or respirators are rated according to the

A

B

C

Figure 5.19 Respirators are available in two main categories. Air purifying respirators such as the disposable toxic dust mask (a), the chemical cartridge mask (b), and the powered air-purifying respirator (PAPR) (c) are shown here. Air-supplying respirators or self-contained breathing apparatus (SCBA) provide clean fresh air from an outside source. Credit: J. Mathison.

filter's efficiency in reducing solid particles of dust, mists, and fumes. Respirators are rated as being 95%, 99%, or 99.97% effective at filtering dust particles.

Filters are also rated according to time-use limitations in using the filter for protection against oil-based chemicals or pesticides in the atmosphere. (NOTE: Legally, hired youth under age 18 are not permitted to handle pesticides.) Filters also have the following designations:

N—Not resistant to airborne oils. Becomes plugged quickly.

R—Resistant to airborne oils for up to eight hours.

P—Oil proof. Possibly resistant to airborne oils for more than eight hours. Change filters after 40 hours of use or every 30 days, whichever comes first.

The disposable particulate respirator in figure 5.20 will have an N95 rating. The filter respirator in figure 5.21 may have an N99.77 NIOSH rating.

Remember: The work situation dictates the respirator to be used. Do not use whatever happens to be hanging on the shop wall.

Use a respirator for its intended use only, and take proper care of the respirator.

Figure 5.20 A double-strap respirator provides a snug fit over the mouth and nose. If a respiratory protective device does not fit snugly, it cannot offer effective respiratory protection from small particles that can damage your lungs. A beard may cause the respirator to fit improperly. Credit: J. Mathison.

Figure 5.21 The chemical cartridge respirator mask has a replaceable filter to trap dust, chaff, and larger particles. These respirators will protect against toxic dust and light chemical vapors. They do not supply oxygen. Credit: J. Mathison.

Poorly fitted respirators provide little or no protection. Glasses, gum or tobacco chewing, facial hair, or even stubble can prevent a respirator from sealing properly. A human hair can average 75–100 microns in diameter; contaminants can be anywhere from 0.2 to 16 microns in diameter. Workers should be clean-shaven for good protection. For people wearing glasses, adapters are available for securing prescription lenses inside the face-piece of a full-face respirator.

A handkerchief over the nose will not filter gases, fumes, or small particles!

Use and Care of a Respirator

Respirators must be properly cared for if they are to protect the lungs. The respirator body and straps must be cleaned regularly with warm soapy water and rinsed thoroughly. Filters must be changed often. Dirty filters will prevent the wearer from breathing normally.

Noise Hazards and Hearing Protection

Farm equipment can generate high levels of noise, which poses serious health risks to people who work long hours around this equipment. Hearing damage seldom occurs with one loud noise. Instead, it results from exposure to loud noises over an extended period of time.

What Is Noise?

Sound is created by anything that causes pressure waves in the air. Different wave sizes, or frequencies, are formed by different levels of shock to the air. Unwanted sound is called "noise."

All sound, including noise, is measured in *decibels* (dB). The unit of measurement is shown by the designation dB(A). A decibel meter measures the dB level. The "A" represents the sound scale used for the measurement.

To understand this concept, let's assign a measurement of 10 to the sound scale. This would mean that an increase in sound from 70 dB(A) to 80 dB(A) is 10 times louder. A 90 dB(A) sound is 100 (10 x 10) times louder than a sound at 70 dB (A).

Not all sound levels are a hazard. Understanding typical loudness levels of common sounds helps workers know if the sound level is unsafe. Consider the decibel levels (table 5.1) of common sounds on the farm.

Table 5.1. Decibel levels of common sounds.

dB(A) Level	Sound Source
15	Whisper
50	Gentle breeze or babbling brook
60	Normal talk level
85	Tractor at idle engine speed
90	Chopping silage (no cab) or lawnmower at full throttle
100	Tractor at work or table saw in use
110	Combine at work or stereo with headphones set at mid-volume
120	Bad muffler or rock concert
140	Shotgun blast or jet engine

Sound levels cause hearing loss at about 85 dB(A). Hearing loss occurs more quickly with louder noise. See Table 5.2 for time exposure to various sound levels that can lead to hearing loss.

People don't adapt to loud noise—they lose the ability to hear loud noise.

Table 5.2. Permissible noise exposures.

Sound level dB(A)	Duration (hours)
90	8
92	6
95	4
100	2
105	1
110	1/2
115	1/4

Loud music or farm equipment can cause hearing loss.

Sound waves have pressure. High frequency sound waves have greater pressure than lower frequency sound waves. This pressure pushes on the eardrum.

Hearing loss occurs over time. Deafness and loss of hearing usually occur with high frequency sounds rather than lower frequency sounds.

Hearing is lost when auditory nerve endings are exposed to the same frequency of sound for extended time periods. The nerves lose their ability to recover from that hostile frequency. The ability to hear that sound frequency is then decreased forever.

Many people have some hearing loss before they even know it. Workers should check to see if any of the following are true in the presence of loud noise. If so, some hearing loss may already be present:

- ears ringing
- noises in their head
- their speech sounds muffled
- they have to shout to be heard by someone next to them

Hearing loss accumulates over time and cannot be reversed. Hearing aid assistance may be necessary. Many older farmers have developed hearing problems over time. Hearing loss also occurs in young workers. With knowledge gained here, younger farmworkers can avoid unnecessary hearing loss.

If people talking to one another need to raise their voices to be heard an arm's length away, the noise is probably loud enough to damage their hearing.

Hearing Protection

The first step to hearing protection is reducing excessive noise. Hearing protection starts in the farm shop with maintaining the exhaust and muffler system (figure 5.22) of the tractor. Machine parts cause loud noises when they are not well-lubricated or properly adjusted.

Figure 5.22 A straight pipe used for the exhaust or a worn-out muffler will increase noise levels coming from the engine. Muffler condition should be part of a safety audit. Credit: J. Mathison.

The answers to these questions help identify a a strategy for hearing protection:

- What farm tasks require hearing protection?
- Where on the farm is the highest noise level likely to be found?

Reduction of excess noise levels may require a soundproofing barrier between the ear and the source of the noise. Soundproof tractor cabs are designed to reduce sound levels.

Types of Ear Protection

Commercially available hearing protection devices are recommended. The choices are acoustical muffs or ear plugs.

Acoustical Muffs

Acoustical muffs, or earmuffs (figure 5.23), are effective in reducing sound level at the ear. They cover the ear and ear canal to provide a barrier to sound. They do not block out all sounds, though, so conversation for information and safety purposes is readily heard.

Figure 5.23 Acoustical ear muffs offer the greatest level of hearing protection because they cover the entire ear and ear canal. Credit: J. Mathison.

Ear Plugs

Ear plugs are made to fit into the ear opening (figure 5.24). A snug fit is necessary for effective sound reduction. Ear plugs can be a source of ear infection, so they must be kept clean and sanitized. Do not share ear plugs with others, because ear infections can be spread this way.

There are two types of ear plugs:

- **Formable plugs**—These plugs are compressed before inserting into the ear. They expand to fill the ear canal. One size fits all.
- **Preformed plugs**—These plugs come in many sizes and must be fitted to the individual's ear. They usually have a cord attached between each plug, making them more difficult to lose.

Ear protection devices are ranked by their noise reduction rating (NRR). An NRR31 rating signifies noise will be reduced by as much as 31 decibels under ideal conditions. However, in actual work situations only about half as much noise protection is obtained from any hearing protection device because of poor fit or improper use. Most professionals recommend cutting an NRR in half. For example, in a work area with 100 dB(A) noise levels, hearing protection with an NRR of 31 dB reduces the noise level about 15 decibels to 85 dB(A), which is still in the danger zone. So that type of hearing protection is not sufficient for that particular job.

Cotton stuffed into the ears does not offer hearing protection!

Figure 5.24 Ear plugs offer hearing protection, but not as much as full-ear coverage protection devices. Credit: J. Mathison.

Farmstead Chemicals

Pesticides are chemicals that kill pests. The U.S. Environmental Protection Agency's Worker Protection Standards (WPS) restrict any hired worker under the age of 18 from handling any type of pesticide. This is stricter and supersedes the Hazardous Occupations in Agriculture (AgHO) regulation. However, neither the WPS nor the AgHO regulations apply to family members.

Many other chemicals are used on farms besides pesticides. Exposure to some chemicals not regulated under pesticide laws is likely.

The beginning farmworker may be assigned to the milking parlor of a dairy farm, the animal treatment area, a livestock center, the field crop area, or the farm shop. Each location comes with hazards to understand.

Dairy farm—Work involves using cleaners and sanitizers. Acid rinses, alkaline compounds, chlorine, and iodine materials are commonly used on dairy farms. These can damage skin and produce toxic fumes.

Animal treatment area—Some materials are potentially hazardous. Animal medications may be applied externally or by injection. Young people are often trained to administer vaccinations. The needles can expose workers to vaccines or puncture wounds, as well as disinfectants.

Livestock center—Chores can range from baby pig care to feeding and care of beef steers. The work there parallels the work of the dairy industry. Prescribed medications may be mixed into the animals' drinking water. Foot bath chemicals are mixed to treat foot health problems. Use of cleaners and sanitizers is common.

Field crop area—work will often be assigned to high school–aged workers, with the exception of pesticide application. Hauling fertilizer and lime is a dusty chore. Those particulates can create respiratory health risks and skin irritation.

Farm shop—Farm equipment becomes greasy and dirt-covered. Degreasers and solvents may be needed to clean the parts. Sulfuric acid will be encountered while servicing tractor batteries (see Chapter 2). These materials are hazardous.

Every year new products are added to the long list of chemicals used on the farm. It is impossible to discuss here all farmstead chemicals. This section provides more details on the chemicals mentioned above.

Know what the chemicals can do and use precautions!

Animals and Chemicals

Working with dairy, livestock, and small animals often requires the use of a variety of chemical products (figure 5.25). Animals must be kept clean and healthy. Equipment used with animals must be disinfected. Unhealthy animals must be treated.

Figure 5.25 A young farm worker should not be surprised that beginning-level jobs will involve cleaning equipment. Dairy facilities, for example, require use of a variety of cleaners, degreasers, and sanitizers to meet milk inspection standards. Credit: J. Mathison.

Disinfectants are used with livestock to reduce infectious organisms. Udders and teats of dairy cows are disinfected with individual sanitary wipes. Teat dips are used before and after milking to reduce bacterial infection. Foot baths contain copper sulfate solutions to control and prevent foot rot organisms from destroying hoof tissues of cattle, horses, and sheep.

Milking equipment, milk pipelines, and bulk tanks must be cleaned and sanitized. Butterfat and protein particles must be removed by degreasing chemicals. The milking equipment components must also be sanitized to prevent growth of harmful microorganisms.

Livestock equipment must be disinfected to prevent spread of disease from one group of animals to others or from one farm to another. Weigh scales and head locks are treated with disinfectants applied by pressure-washing equipment. Livestock tools, such as dehorning and castration equipment, must be sterilized after each use.

Many animal medicines or pharmaceuticals are also agricultural chemicals. Dairy and livestock must be treated for disease or vaccinated to prevent disease. Injections may supplement nutritional needs of the animals. High-school-age farmworkers are often trained to assist with these injections.

Practice safe work habits to prevent unnecessary exposure to the active ingredients in products:

- Read product labels to understand the safety requirements of the product.
- Do not mix chemical solutions without adult supervision.
- Use proper personal protective equipment to protect eyes, skin, and lungs.

Note: The maturity and strength of a young worker must be considered when assigning animal care tasks.

Young farmworkers are often assigned to work with animal cleaning and sanitation products.

Fertilizer and Lime

Fertilizer and lime are necessary for plant growth. Fertilizer provides the plant with essential elements such as nitrogen, phosphorus, and potash. Lime neutralizes soil acidity to make fertilizer elements more available to the plant. Fertilizer materials are applied in dry, gas, or liquid form. Lime is applied in a dry powder or liquid form.

Exposure occurs when fertilizer is handled. Operator exposure increases without protection.

Fertilizer is a hygroscopic material. This means it attracts moisture. As it pulls moisture from the skin, eyes, nose, or mouth, tissues can blister and burn.

Lime in the hydrated form is also a hygroscopic material. Hydrated lime is often used to treat barn alleyways as a disinfectant and as a fast-acting soil amendment.

Workers should wear a long-sleeved shirt, long pants, and eye protection while handling and applying these materials. A toxic particle dust mask is also recommended.

Machinery and Chemicals

Farm machinery must be maintained and repaired. Many chemicals are used in maintenance and repair tasks. The chemicals (figure 5.26) include but are not limited to:

- fuel
- oils and lubricants
- degreasers
- antifreeze
- battery acid
- solvents

Each of these materials can be **toxic**, **caustic**, or **flammable**.

Toxic materials poison a person if they are ingested, spilled on the skin or in the eyes, or inhaled. Petroleum products and antifreeze can be fatal if swallowed.

A *caustic* material burns skin tissues quickly. For example, battery acid burns skin and clothes. Solvents can dry the skin and cause irritation.

Flammable materials can explode or ignite and burn violently. Petroleum products and cleaning solvents are class B fuels (see Fire Safety on page 256).

Safe work habits should be practiced in all areas of the farm. Shop safety with chemicals should include:

- use of personal protective equipment, such as goggles, chemical gloves, and aprons
- understanding label directions for the material's use in mixing and application
- adult guidance for areas of confusion

Special note: Shop rags pose a hazard as well. The rags can be soaked in toxic or caustic material, such as battery acid, or flammable materials, such as oil. See Oil Change Safety in Chapter 2 for information about disposing of used shop rags.

Figure 5.26 Exercise care when using all farmstead chemicals. Spills can pose hazards such as slips and falls. Follow cleanup and proper disposal procedures on the product's label. Credit: J. Mathison.

Young farmworkers are often assigned to clean equipment and move crop supplies.

Anhydrous Ammonia

Plant growth is improved with fertilizer application. Nitrogen is an element responsible for green, healthy, productive leaves. Soils usually lack nitrogen, so this element must be added to the soil.

Anhydrous ammonia contains 82% nitrogen. Nitrogen solutions are caustic. Caustic chemicals can burn plant and human tissues.

Hired youth younger than age 16 are forbidden by the Hazardous Occupations Order in Agriculture regulations from handling or using anhydrous ammonia. There are no exceptions to these regulations based upon a supplemental training program. Young workers who are assigned the task of working with anhydrous ammonia must tell their employer they are not permitted to do so.

Even so, youth may work around anhydrous ammonia and should understand its hazards.

Stored under pressure, anhydrous ammonia exists in liquid form. In the air, anhydrous ammonia becomes a gas. Pressurized tanks are used to store and deliver this form of fertilizer to application tanks used on the farm.

Anhydrous means without water. Anhydrous ammonia is quickly attracted to any form of moisture. Soil moisture absorbs the fertilizer rapidly.

Just as soil moisture reacts quickly with anhydrous ammonia, so does the human body. Moist skin, eye, and lung tissues react with ammonia and cause severe burning. Severe health problems will result from improper handling and application of anhydrous ammonia. **Anhydrous ammonia can result in permanent damage to the lungs**.

Using anhydrous ammonia is more complex than applying dry, granular fertilizer. Pressurized tanks, control valves, and pressure hoses must be in working order and used properly. The operator must follow specific procedures exactly. Safety equipment must be nearby and not stored away from the job site.

The danger of using anhydrous ammonia comes through the risks of handling the material. Hired workers younger than age 16 are not permitted to handle anhydrous ammonia.

Pesticides

The risk associated with the use of a pesticide is based on the product's toxicity and the applicator's exposure to the product. *Toxicity* means how deadly the product is to people. This principle is often referenced by the following equation:

risk = toxicity x exposure

To a certain extent, the applicator can control the toxicity of the pesticide by choosing a product with lower toxicity, if available. The exposure part of the equation is based on the length of time and the area (of the body) exposed. Workers who apply pesticides can significantly reduce their risk and potential exposure by wearing personal protective equipment (PPE). This section discusses agricultural pesticides from a youth information standpoint.

Pesticide Use Restrictions

Imagine this scenario: A 15-year-old was hired to work at a neighboring farm, having passed the safe tractor and machinery certification program. On the first day of work, the farmer assigns the youth to rinse pesticide containers for return to the dealer and to burn pesticide bags. This may sound like a safe job to do, but is it actually safe?

Youth younger than age 18 who work for hire are prohibited from using many agricultural pesticides under EPA's Worker Protection Standards, so no, they cannot do this job. Even if they were working on their own family's farm, they should not perform these tasks. Agricultural pesticides may come in dust form, granular particles, liquid concentrates, or solutions. They may seem safe, but they are complex chemical compounds with very serious effects on humans.

Effects of Pesticides on People

Exposure to pesticides produces a variety of symptoms, including headache, nausea, stomach cramps, diarrhea, chills, fever, fainting, and possibly paralysis and death. Some people mistake pesticide poisoning for what they call the "summer flu."

Ag chemical exposure can lead to a variety of symptoms, including paralysis and death.

Signal Words and Categories

Every chemical label must display signal words (figure 5.27). These industry standard words tell the user the toxicity (figure 5.28) of the product. Remember, *toxicity* means how deadly the product is to people.

Signal words found on agricultural chemicals include:

- danger-poison (skull and crossbones included)
- danger
- warning
- caution

Figure 5.27 The most toxic of chemicals will display the signal words "danger-poison" along with the skull and crossbones. "Peligro" is Spanish for "danger." Young farm workers are prohibited from working with or being exposed to these chemicals. Credit: J. Mathison.

Figure 5.28 The word "toxic" means deadly. Toxic materials can produce illness-like effects, or they may be deadly. Credit: J. Mathison.

Danger-Poison

Category I chemicals show the "Danger-Poison" signal words. A skull and crossbones symbol is included on the label. These chemicals may be corrosive (can burn) to the eyes and skin and lungs. Ingesting less than a teaspoon of the chemical can kill a 150-pound person. Most of these chemicals are "restricted use" materials due to increased risk to human health and/or the environment. They require a certification to purchase and use.

Danger

Category I chemicals marked "Danger" can cause severe skin irritation and eye damage.

Warning

Category II chemicals use the signal word "Warning." Skin and eye irritation lasting longer than one week can result from exposure to these products. Ingesting a tablespoon of some Category II chemicals can be fatal. These are considered restricted-use pesticides.

Caution

Chemical labels using the signal word "Caution" are much less toxic products to use. Mild skin and eye irritation results from exposure to these chemicals. Nearly one pint of the material must be consumed to be fatal to a 150-pound person. Most pesticides sold over-the-counter to consumers use the signal word Caution.

Learn the signal words used on pesticide containers.

Agricultural Pesticide Exposure

Exposure to agricultural chemicals is not necessarily a harmful event, but repeated exposure over time can be harmful. Exposure can be minimized by wearing personal protective equipment (PPE) (figure 5.29).

The handling and application of pesticides is prohibited for youth younger than age 18 working for hire.

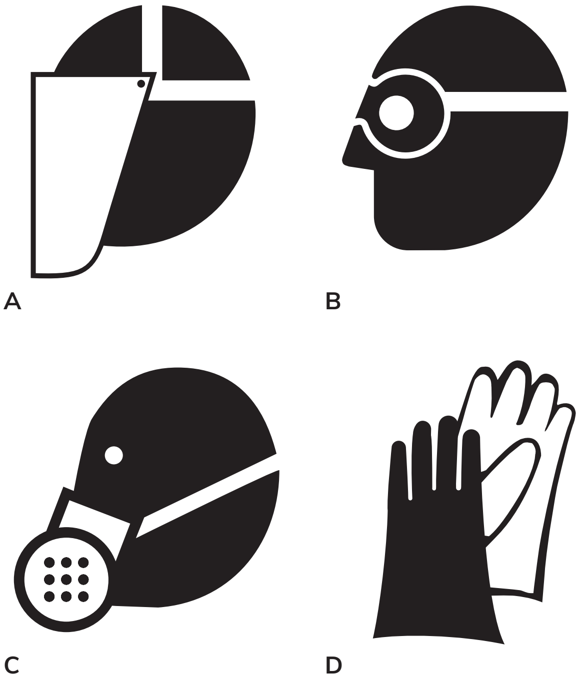

Figure 5.29 The personal protective equipment (PPE) that should be used when handling pesticides, strong detergents, sanitizing chemicals, degreasers, and battery acid. You should also wear long sleeves and pants and a rubber or plastic apron. Read the chemical label for the PPE to use. Credit for all 4 photos: Association of Equipment Manufacturers.

Chemical exposure can occur in four ways:

- oral (mouth)
- dermal (skin)
- inhalation (lungs)
- ocular (eye)

The following section examines each method of exposure more closely.

Oral Ingestion (By Mouth)

Hands can be contaminated with pesticides when the container is touched, even if the container seems clean. Small amounts of the chemical may then end up on cigarettes, chewing tobacco, food, or drinks touched by contaminated hands. Consuming a small amount of pesticides through food is a common means of ingestion. Hands are an oral source of exposure.

Dermal (Skin) Exposure

Pesticides may be absorbed through the skin. Urinating while your are pesticide-covered can cause exposure. Some people mistakenly think tough, calloused hands reduce the risk of pesticide entry through the skin. Even wiping a sweaty forehead or the back of the neck risks dermal exposure to those more sensitive tissues.

Touching treated surfaces or handling empty containers may cause dermal exposure. Walking through a recently treated field can risk dermal exposure also.

Inhalation (Breathing) Exposure

Breathing pesticide or agricultural chemical mists, vapors, or dusts exposes the lungs to the product. Exposure can occur while mixing granular and powder forms of pesticides and during the burning of empty containers. Inhalation exposure provides the fastest route of toxins into the bloodstream.

Improper handling of agricultural pesticides can result in the production of toxic fumes and vapors.

Ocular (Eye) Exposure

Eyes are at risk of exposure and damage from splashes of liquid chemicals and dust from granular pesticides during handling, mixing, or rinsing of containers.

Pesticide labels provide specific requirements for the PPE to provide maximum protection and reduce pesticide exposure.

PPE use does not make it legal for hired youth younger than age 18 to handle or apply pesticides.

Housekeeping

Introduction

Tractors, machinery, and electricity are not the only sources of occupational hazards on a farm. Dangers in work areas must also be considered. The safety of every worker is enhanced by following safe storage and use practices and cleaning regularly.

This section discusses the relationship between good housekeeping and safety.

Importance of Housekeeping

Lack of housekeeping creates hazards (figure 5.30). Picking up, wiping up, sweeping up, and removing scraps and waste all help to control hazards. Storing objects properly makes the work area safer. Unorganized spaces and unplanned methods of work often indicate an unsafe place to work and an increased risk for injuries.

Figure 5.30 Even on a temporary basis, this is not proper pesticide storage or disposal. While the operator is in the field, children or animals could come in contact with deadly pesticide residue. Credit: PSU Ag Safety.

Several topics are important when discussing good housekeeping on the farm:

- work site adequacy
- environmental hazards
- storage needs
- cleanup practices

Work Site Adequacy

The work site must be safe all day; from the beginning to the end of the workday. Check these safety hazards:

- Are aisles and passages wide enough and high enough for safe movement?
- Is there adequate lighting?
- Is there adequate ventilation?
- Are the floors and ramps slip-resistant?
- Are pits and floor openings covered?
- Are sharp edges eliminated?
- Are exits marked and clear of obstruction?
- Are hoists sized to the needs of the business?
- Are sink and toilet facilities clean and sanitary?

Young workers cannot change the physical layout of the farm shop or storage areas. But they can develop the skills and safe attitudes necessary to help maintain the facilities. Shop cleanup is a valuable job skill. Some things they can do to make facilities safe and healthy are:

- Report unsafe work areas.
- Report burned-out lights.
- Put tools, materials, and unused supplies in their correct places.
- Sweep floors.
- Clean oil and grease spills from floors.
- Clean sinks and toilet facilities.

As one farmer says to young workers, "If you have time to lean, you have time to clean." When not assigned to a specific job, young workers can be an asset to the farm by completing housekeeping chores.

A clean farm is a safe farm.

Environmental Hazards

The farm environment has many health risks reduced by good housekeeping. Dust and excessive moisture are common. Each poses a special problem.

Dust

To build a fire in a fireplace, kindling materials usually get the fire started before larger logs are added. Dust, which is dry, has a low kindling temperature. Dust can burn explosively, much like the fumes from gasoline.

All dust from the farmstead can't be removed. No one expects that level of cleanliness, but unnecessary dust buildup near sources of heat increases the risk of fire. Some cleaning near these sources could prevent a fire.

Excessive Moisture/Slippery Floors

Water, oils, and other substances cause floors to become slippery. Take a few minutes to clean the walkway. Use a floor-drying compound or sand to reduce slippage and to clean the area. Place a warning sign or barricade at the location until the floor is dry and safe.

Storage Needs

Proper storage creates an organized and safe workspace. No one wants to waste time looking for tools or materials. Safe storage helps prevent lost work time from injuries. Improper storage can lead to a risk of fire.

Heavy and long objects—Heavy and long objects must be stored correctly to prevent trip, fall, or falling object hazards. Long wood or pipes should be stored on specially designed racks. Storing long objects under benches where they stick out creates a tipping hazard. Heavy objects should be stored as close to the floor or ground as possible to minimize the risk of falling and injuring workers.

Fuels and lubricants—Proper fuel storage is an important housekeeping chore. Liquid fuels may be volatile, which means they produce gaseous vapors that easily ignite. Liquid fuels also have a *flash point*, which is the temperature at which gaseous vapors ignite. For more information on the dangers of fuels and lubricants, see Class B Fires below.

To keep the fuel area as safe as possible, follow these good housekeeping rules:

1. Keep caps on all fuel containers.
2. Use only approved diesel and gasoline storage containers. Green or yellow containers are used to store diesel fuel. Red containers are used for gasoline storage.
3. Keep areas around refueling stations free of fuel spills.
4. Use an approved absorbent compound to clean up fuel spills.

Cleanup Practices

Work areas cannot be perfectly clean at all times, but they can be made safer to work in at all times. Clean as work progresses to eliminate major cleaning chores later and create a safer workspace.

- Clean all spilled material immediately and safely. Avoid procedures that could create airborne inhalation hazards.
- See Oil Change Safety in Chapter 2 for information about safely storing and disposing of used shop rags.
- Use hand cleaner or disinfectant before eating or drinking.
- Dispose of animal health equipment tools and supplies as directed. Needles used to administer animal vaccines are sharp, and the user can be accidentally stuck. If left uncapped, or if not disposed of properly, they create a hazard to people and livestock. Follow the manufacturer's directions for safe storage and disposal of needles and syringes.
- Manure and mud are slippery. Both can be brought into the shop area on machinery or shoes. Clean manure and mud from alleyways and high-traffic areas to decrease the risk of falls.

Oily rags thrown in a pile can be a fire hazard. Store them in a closed metal container.

Fire Safety

Introduction

Fires can happen in the home; in the shop, barn, or silo; and around farm machinery and vehicles. Grease can catch fire in the kitchen or shop. Flammable materials can be ignited during welding or metal cutting. Dust and crop debris can be ignited in or on machinery. Spontaneous combustion can occur in stored damp hay, with improperly stored silage, or in piles of oily rags. Electric circuits can overheat and cause fires.

Many people panic when a fire occurs. Panic is unnecessary; instead, understand what causes fires, and learn the basics of fire extinguishing methods.

This section provides information on fires in agricultural buildings and structures.

Definitions

Auto-ignition: A situation in which flammable materials spontaneously catch fire when stored near an open flame or where heat can build up.

Combustible: Able to be burned. In the case of liquids, those with a flash point at or above 100˚F.

Flammable: Often used interchangeably (and sometimes mistakenly) with the term "combustible." In the case of liquids, those with a flash point below 100˚F.

Flash point: The lowest temperature at which a solvent will produce vapors in enough concentration to ignite when brought near a source of heat.

Kindling point/ignition point: The lowest temperature at which a solid material will ignite when brought near a source of heat.

Spontaneous combustion: The phenomenon in which a material unexpectedly bursts into flames without apparent cause.

Vapors: The gas form of substances that are normally in the solid or liquid form.

Volatility: The tendency of a liquid to vaporize or evaporate into the air. Gasoline is an example of a volatile substance.

Fire Triangle

Three things are necessary for a fire to start and continue to burn: fuel, heat, and oxygen (figure 5.31). This is represented as the fire triangle. Fuels can be a variety of materials (discussed below). Heat sources can be electrical, open flame, sparks, and chemical reactions. Oxygen is part of the chemistry supporting the fire. Without any one of these factors, a fire cannot exist.

Fires are classified by letter (figure 5.32) according to the fuel burned. Categories of fire common to agriculture and rural residences are Classes A, B, and C, discussed below.

Fires are classified by letters representing the fuel involved.

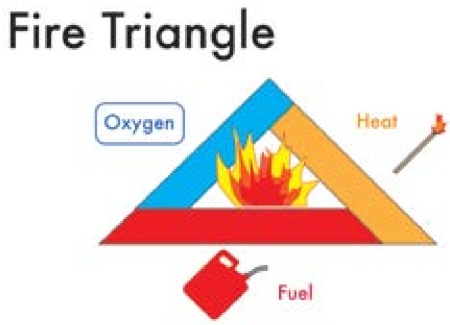

Figure 5.31 To support a fire, three items must come together with a chemical reaction. Heat, fuel, and oxygen (air) must be available to support a fire. Credit: J. Mathison.

Figure 5.32 Fires are classified by letters representing the fuels that support them.

Class A fires involve wood, paper, rubbish, plastic, and crop materials

Class B fires involve burnable liquids such as grease, oil, and fuels.

Class C fires involve electrical sources such as motors, wiring, switches, and connections.

Credit: J. Mathison.

Class A Fires

Class A fires involve wood, paper, rubbish, plastic, and crop materials. These fuels have a "kindling point" or "ignition point," the lowest temperature at which the substance will ignite near a source of heat. Small pieces of wood burn more quickly than a large log, for example, because small pieces of wood have a lower kindling point than larger pieces.

Dust (figure 5.33) from Class A materials can burn quickly and violently. Dust has a low kindling point.

Figure 5.33 Dusty, dirty conditions in agriculture contribute to increased fire hazards. What materials in this picture are considered Class A fuel sources? Credit: PSU Ag Safety.

Class B Fires

Class B fires involve liquids that produce vapors, which can burn. When liquids give off enough vapors to burn, the fuel is at its "flash point."

Three fuels can serve as examples of vapor-producing liquids. Gasoline is the most volatile liquid fuel and produces vapors that burn quickly and violently. It has a low flash point. Diesel fuel and paint thinners are less volatile (produce fewer vapors) and have a high flash point. Diesel fuel and paint thinners burn slowly when an open flame is placed near the fuel surface. Acetylene gas for welding (figure 5.34) and cutting is the product of a chemical reaction involving liquid elements producing gas. These vapors burn explosively. Acetylene gas has a flash point of about 0 degrees Fahrenheit.

Figure 5.34 Welding sparks from electric arc welders and oxyacetylene gas welding equipment can create the spark that ignites nearby flammable materials or vapors. Credit: J. Mathison.

Heavier or Lighter Than Air?

Some fuel vapors are heavier than air and settle to the lowest point nearby. Gasoline (the most volatile liquid fuel) vapors are heavier than air and settle to a low point in a shop or enclosed space. Propane vapors are lighter than air and rise into the atmosphere. Diesel fuel has moderate volatility, so the vapors occur near the surface of the fuel itself.

Precaution: When working on a vehicle inside a shop or garage, do not allow gasoline to spill. Vapors may travel across the floor and ignited from a hot water tank pilot light, welding sparks, or the sparks from a dropped, broken portable shop light.

Heavier or Lighter Than Water?

Class B liquid fuels have weight or density. Some fuels float on water, and others sink beneath the surface. Gasoline and diesel fuel float on the surface of water, while grease sinks beneath the water. Fuel spilled on a body of water can ignite and burn on top of the water.

Precaution: A fuel spill on a farm pond or slow-moving stream should be reported to local fire officials immediately.

Vapors Concentrated in the Air

As vapors (figure 5.35) of gaseous products gather in an enclosed space, they may ignite when a light switch is simply turned on. There is a momentary arcing of electrical current behind the light switch unless the switch is a snap action device. Acetylene gas leaking from a cylinder into a closed storage room can explode when a light switch is turned on. Acetylene tanks should be drained properly. Be aware of this hazard.

Hint: Smell the air in the acetylene storage area before turning on the light switch. No acetylene vapors should be detected. Prevent an explosion by smelling the air first.

Because of the volatility of Class B fuels, auto-ignition may occur near open flames or in storage areas where heat can build up.

Vapors can be explosive.

Figure 5.35 Vapors are produced by cleaning solvents, gas, and paints. Vapors that pass off into the atmosphere are termed “volatile.” Credit: J. Mathison.

Class C Fires

Class C fires involve electricity as the source of both fuel and heat. Motors, wiring, switches, and controls can overheat. Overheating is usually caused by an electrical overload. Electrical parts can catch fire. Nearby flammable objects can ignite.

Electricity generates heat. Increased heat in electrical wiring can be expected in any of the following situations.

- The wire size is too small (trying to run an electric motor on a lamp cord).
- The electrical load is too great (e.g., operating a fan, a light, and a vacuum on the same circuit).
- The electrical load is too far away from the electrical source (a 1/2-horsepower electric drill motor operated at the end of a 100-foot extension cord).
- The electrical connections are loose.
- The electrical equipment is malfunctioning.

Electrical equipment also can create sparks during operation. Class A and B fires can be ignited by electrical overloads and sparking.

Fire Prevention and Control

Fires can be prevented and controlled. Fires are often unexpected, but their behavior is usually predictable. People are unpredictable and often panic when faced with a fire.

This section discusses fire prevention and control as a means of helping young agricultural workers deal calmly with unexpected fires.

Fire Prevention

Most fires can be prevented. Remember the science of the fire triangle. Fuel, oxygen, and heat must react together for a fire to occur. Without any one of these factors, a fire is not possible. A fire prevention program can be built around knowledge of the fire triangle.

Several steps lead to a sound fire prevention program. Work-site analysis, maintenance, housekeeping, and training in fire prevention and control are proven methods of reducing the risk of fire.

Work Site Analysis

Fire hazards should be surveyed at each farm. Flammable materials should be identified and stored properly. Fire extinguishers must be easily located and readily available. Fire extinguishers should be professionally inspected and/or recharged on an annual basis.

Maintenance and Housekeeping

Equipment and facilities must be maintained and in working order. Regular maintenance schedules should be followed. For example, worn bearings on a motor shaft can overheat and ignite nearby flammable materials. A regular lubrication schedule can reduce the risk of fire.

Good housekeeping helps prevent fires (figure 5.36). Clean up oil-soaked rags to reduce the risk of sparks igniting the cloths. See Oil Change Safety in Chapter 2 for information about disposing of used shop rags.

Fire Prevention and Control Training

Everyone working on the farm, whether hired workers or unpaid family help, must be a partner in the prevention and control of fires. All job descriptions for workers should include:

- regular fire hazard inspection
- training in fire extinguisher use
- good housekeeping procedures

Each person is responsible for knowing fire prevention and control procedures.

Figure 5.36 Sloppy housekeeping contributes to potential fire hazards in farm shops and other structures. What class or classes of fire (A, B, or C) could occur in the shop shown in the photo? Credit: J. Mathison.

People tend to panic in a fire. This behavior causes further panic and poor decision-making.

Fire Extinguishers

Fire extinguisher use is identified by a pictorial attached to the extinguisher body showing the type of fire for which they should be used (figure 5.37). In an emergency, these standard graphics give us instant information about the extinguisher.

Water-type extinguishers—Contain water under pressure. The water cools the fire to extinguish it. Use them for Class A fires only. Water spreads grease fires and conducts electricity. Water sprayed on an electrical fire will conduct the electrical charge back to the user. Electrocution may result.

Water-type extinguishers are made of stainless steel and have a pressure gauge and a long hose (figure 5.37).

Chemical extinguishers—Contain a dry chemical powder. They can be used on class A, B, or C fires, so they are also called ABC extinguishers. The dry chemical suffocates the fire by eliminating the air. A small amount of material can extinguish an equipment or motor fire quickly. The dry chemical does leave a residue to clean up. The 10-pound, dry chemical extinguisher is recommended for many uses (figure 5.37). The dry chemical powder extinguisher is identified by its short, thick, red container with a bright metal nozzle next to the pressure gauge.

Another chemical extinguisher is the halon extinguisher. It contains a gas that interrupts the chemical reaction when fuels burn. This type of extinguisher is often used to protect valuable electrical equipment such as computers because they leave no residue to clean up.

Carbon dioxide extinguishers—Contain carbon dioxide (CO_2) gas. This extinguisher can be used on small class B and C fires. The pressurized CO_2 gas contacts the air and forms dry ice. The fire is cooled by the dry ice. It leaves no residue.

There are limits to the CO_2 extinguisher's use. Larger fires will require a greater capacity for control than what this extinguisher can provide. Also, the dry ice is so cold it can burn the skin if touched.

CO_2 extinguishers are identified by a red container with a larger black funnel-shaped pivoting nozzle near the pressure gauge area (figure 5.37).

The ABC (figure 5.38) type of extinguisher is the most practical extinguisher for the home and farm because it can be used on the most common types of fires, and it is readily available from commercial retail stores.

DO NOT TREAT FIRE EXTINGUISHERS AS TOYS. Squeezing the trigger to discharge the fire extinguisher even once will be enough to drain the pressure from the extinguisher. When it is actually needed, it will be worthless.

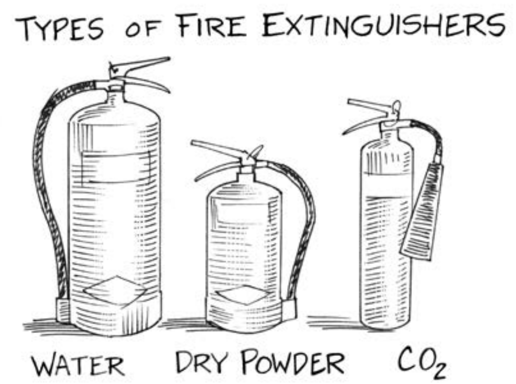

Figure 5.37 Fire extinguishers must be used for the class of fire for which they are rated. Credit: J. Mathison.

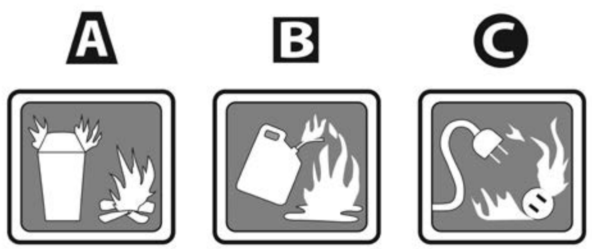

Figure 5.38 People do not have time to read directions in a fire emergency. Symbols on the fire extinguisher represent the type of fire. If you saw these pictorials on fire extinguishers, what class or classes of fire could you use them for? Credit: J. Mathison.

Fire extinguishers should be regularly inspected for leakage.

Using a Fire Extinguisher

To use a portable fire extinguisher, follow the steps abbreviated "PASS:"

1. Pull the pin.
2. Aim at the base of the fire.
3. Squeeze the trigger.
4. Sweep from side to side.

Remember the acronym --PASS!

Important note: Always aim at the base of the fire. This is important for two reasons. First, a small fire extinguisher has limited material. It will be wasted aiming at the top of the flames. Secondly, the fire extinguisher material will form a barrier above the fire. The flames can roll up under the barrier toward the extinguisher (and the person holding it).

Fire Preparedness

Being prepared to control a fire is different than working to prevent fire hazards. A number of steps can help prepare for a fire emergency. These practices can be used at home, on the farm, or other places of employment.

- All family members and employees should be trained in fire prevention and control measures.
- Local fire company phone numbers should be accessible to all people involved with the farm, especially if 911 isn't available in the area. Cellphones may be the best form of communication if phone lines are burned by fire.
- Written directions to the home or farm should be stored near each landline phone. In a panic, people may forget simple directions or be unable to state them clearly.
- Provide the local fire company with a detailed map of the farm, including pesticide and fertilizer storage areas, manure pits and lagoons, and fresh water sources such as ponds and hydrants. The fire company may keep these on file, or the maps could be available in a weatherproof box at the farm lane.
- Install smoke alarms and carbon monoxide detectors. Test the batteries regularly and replace them as needed.
- Schedule regular fire training and fire drills with the family and employees.

- Supply an ABC fire extinguisher on all tractors and self-propelled machines, such as combines and other harvesters. (figure 5.39).

Being prepared for a fire is good insurance. Preparation allows people to react in a focused and safe manner.

Family members and employees should be prepared for a fire.

Figure 5.39 All tractors should have a dry chemical-type fire extinguisher on board. Today's high-priced tractors and equipment should be fire control ready. What class(es) of fire will the dry chemical extinguisher control? Credit: J. Mathison.

Electrical Hazards

Introduction

Agriculture often uses electricity as a tool. Previously labor intensive jobs are now completed with the help of electrical devices. The dairy industry uses compressors, vacuum pumps, refrigeration units, motors, and controls for all kinds of tasks. Grain producers use crop driers with fans and augers. Swine and poultry producers rely heavily on controlled ventilation and automatic feeding systems.

This section discusses the hazards posed by electricity. New farmworkers will use many of the systems mentioned. Each year, 30 to 40 people are electrocuted on farms. Working safely with electricity is a required skill.

Using electrical current and electrical equipment exposes the user to several hazards such as electric shock, heat, and fire.

Electric Shock Hazard

When a person becomes part of an electrical circuit, they are a conductor of the electrical current (figure 5.40). Because electricity cannot be seen, the hazard is often overlooked until it's too late. Bodily injury and death can occur.

Current flowing through the body will affect the body in some manner. A small amount of current may cause the person to feel a slight tingling sensation. They may also feel a shock, which causes muscular contractions and knocks them away from the circuit. Electric shock may lock their muscles in a contraction that prevents release from the circuit. In severe cases, heart muscle rhythms are disrupted and death results.

Electrical current also produces heat, which can burn body tissues both externally and internally.

Heat and Fire

Electricity can be the source of heat to ignite flammable materials. Electrical fires are common. Current flow in a conductor produces heat because of the conductor's resistance to the flow of electricity. See previous section "Class C Fires" for dangers with electricity.

Electricity can kill.
Be careful!

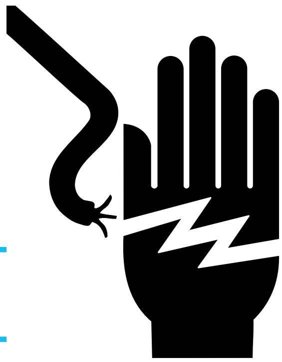

Figure 5.40 The pictorial symbol for electric shock hazard. Credit: Association of Equipment Manufacturers.

Common Electrical Devices Used in Farm Work

Work assignments on the farm may require use of electrical appliances and tools.

Note: A qualified electrician will be necessary to work with the electrical system beyond what is described here.

Distribution panel–Assignments may include turning circuits on or off at the distribution panel (sometimes called circuit breaker panel or fuse box).

Fuses and circuit breakers–These devices found in the distribution panel protect the wires of the circuit from overheating.

Fuses are either a screw-in or cartridge type. A metal strip melts when the circuit is overloaded, and this interrupts the circuit. If the fuse must be replaced, shut off the main power switch before changing.

Circuit breakers look like switches. When a bi-metal strip (containing two different metals) is heated from electrical overload, the metal becomes distorted and causes the circuit breaker to cut the electricity. The overload problem must be corrected, and the switch turned off and then on again.

Ground-fault circuit interrupters (GFCIs)–Ground-fault circuit interrupters can look like an electrical outlet or a circuit breaker. These devices break the circuit in microseconds when a difference in current is sensed. GFCIs are used where moisture is found. Milking parlors and milk rooms, swimming pools, kitchens, laundries, and outdoor receptacles should have GFCI protection. A red reset button and test light area make GFCI devices look different from a regular outlet.

If fuses, circuit breakers, and/or GFCI devices are frequently "blowing," which means turning off and needing to be reset, they should be checked for problems before work continues.

Switches and receptacles–Switches energize circuits. An outlet connects the appliance to the circuit. Careless use can damage the receptacle and appliance. If an electrical switch and/or receptacle is damaged, repairs should be made before use.

UL (formerly Underwriters Laboratories)

Electrical components must meet UL standards (ul.com). Look for the UL symbol (figure 5.41a) to be sure the device has approved safety construction.

Figure 5.41 Electrical components are built to strict safety standards and tested for reliability by the Underwriters Laboratory (UL). Look for the UL label (a) to help ensure the safety of electrical equipment. You may have to operate circuit breaker boxes (b, c) as switches for electrical tools. If the appliance suddenly stops working, then a GFCI, circuit breaker, or fuse may have broken the circuit to protect you and the wiring. Credit 5-41a: UL, LLC Credit 5-41b, c, d: J. Mathison.

Recognizing Electrical Hazards

Electricians are not the only workers who should be safe around electrical circuits. Everyone needs to be! Use the following ideas to be a valuable and safe worker.

Circuit breakers and fuses—If circuits are constantly breaking (shutting off), the circuit is overloaded (figure 5.41b, c, d). Report this information. In the past, items were placed in fuse sockets to prevent the shut-off or even bypass the circuit. Using a larger capacity fuse only adds to the danger. Trying to overcome safety equipment is not a good idea.

Grounding—Three-prong appliance plugs ensure the circuit is grounded. *Never cut off the round prong to make the plug fit.* A two-prong adapter with ground strap should be used if the outlet has only two prongs available.

Lock-outs—Distribution panels or fuse boxes can be fitted with a lock. Lock these boxes to prevent young children and visitors from contacting the wiring inside them. When working with an electrical circuit out of sight of the fuse box, lock the fuse box or controller. This prevents another person from accidentally energizing the circuit while someone is working on it, which could cause injury.

Hostile farm conditions—Dust, moisture, corrosive materials, gases (manure), and physical damage is hard on electrical equipment. Broken or damaged electrical equipment should be reported (figure 5.42).

Extension cords—Many times extension cords are used to operate equipment. Use heavy-duty cords when using heavy-duty tools. Extension cords should not be used as permanent wiring. Do not jerk the extension cord from the wall receptacle by pulling on the cord. Be careful not to cut through the extension cord insulation. Report damaged extension cords immediately.

Underground utilities—Phone, electrical, gas, satellite TV, and dog training wires and pipes may be buried. For public utility locations, call before digging your local public utility. Check with the national directory call 811.com/811-(your)-state, for the phone number or website in each state.

Figure 5.42 Improper electrical wiring methods and materials placed in a hostile farm environment can lead to fires and electrocution of people and livestock. Credit: PSU Ag Safety.

The service is free.

Overhead Power Lines

Many overhead power lines do not have insulating covers. They normally carry current higher than building circuits. If a person or machine becomes part of this electrical circuit, it can be deadly.

Many deaths on farms are due to contact with overhead wires (figure 5.43). Elevators, augers, metal ladders, and irrigation pipes must be moved. These objects are good conductors of electricity, and the operator is usually in direct contact with them through the tractor and implement.

> Machinery contact with overhead wires causes many farm fatalities from electrocution.

To prevent this hazard situation:

- Lower augers and elevators for transport.
- Take notice of low-hanging wires.

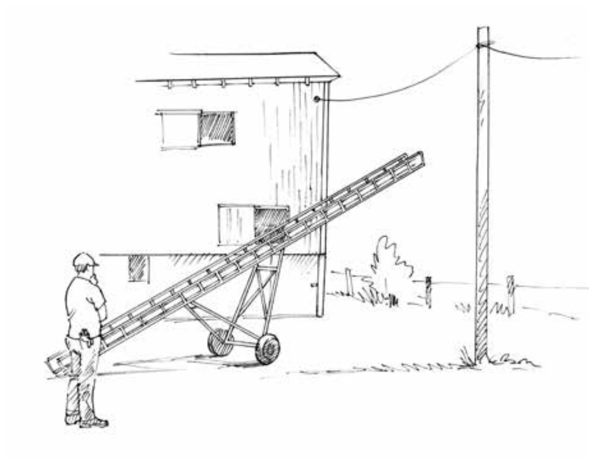

Figure 5.43 Lower the hay elevator or grain auger to avoid contact with overhead power lines. Credit: L. Mathisen.

- Use a spotter while moving equipment under utility wires.

Workers in a tractor or vehicle in contact with power lines should stay in the vehicle, isolated from the electric current. Use a cellphone to call for help. If they have to get out, they should jump clear of the machine/vehicle and land with both feet at the same time. If they put just one foot down, they will complete the circuit and be electrocuted.

Animal-, Wildlife-, and Insect-Related Hazards

Introduction

Farm work may provide unexpected contact with wildlife. Sometimes these contacts can be hazardous. Understand the risks of these exposures. Some animal health problems can be transferred to humans.

Zoonoses

Definition: Zoonoses (or zoonotic diseases) are diseases transmitted between vertebrate animals and humans. These diseases can be transferred in several ways.

Direct Animal Contact

Animal manure, urine, bedding, and products (raw meat, unprocessed milk, hides, hair, etc.) can serve as a source for human infection. Disease-causing organisms and/or disease-carrying insects can be found in and on these products.

Animal manure from animals such as cows (figure 5.44) contains bacteria from the animal's digestive system. For example, *E. coli*, a bacterium found in manure, can cause intestinal disease in people, with nausea and general feelings of ill health.

Figure 5.44 Cattle can transmit ringworm, rabies, and other diseases to humans. Credit: Pixabay CC0.

Animal products such as meat and milk can carry disease-causing microorganisms. Meat can be a source of *Salmonella* or *Listeria*, both of which are bacterial organisms. These organisms can cause fever, nausea, vomiting, and diarrhea. Processing or pasteurization is used to control and eliminate these microorganisms.

Animal hides and hair may harbor insects that can carry disease, bite, or sting a person. Workers who must handle raw animal products are placed at risk for exposure to insects and ticks (see upcoming section on Lyme disease).

Infections of the animal's reproductive tract can be transmitted to people who assist with birthing animals. Sterile, disposable gloves should be worn to protect against harmful organisms. These organisms can enter the body through cuts and scratches. Just as important, infection from a person's hands can enter the animal's reproductive tract and cause disease to the animal. Wash hands thoroughly before and after assisting with an animal birth or any other contact with animals.

Indirect Animal Contact

Soil, plants, and water can be contaminated by animal wastes. Surface water (rivers, streams, reservoirs, and ponds) and ground water (from underground wells) can be contaminated with animal waste. Avoid drinking this water to reduce exposure to potential health risks.

Ringworm is an example of a zoonotic disease.

Stinging Insects and Spiders

Wasps, hornets, bees, and other stinging and biting insects and spiders are found throughout the country. Many farmworkers have been stung by one or more of these pests, with various reactions.

Insect bites create health problems for some people. An extreme allergic reaction to insect venom is called *anaphylactic shock*. This is characterized by swelling of the throat, which can cause suffocation and a sudden decline in blood pressure. Both of these can cause death. A person who has such a reaction must immediately receive emergency medical care. People with a known severe allergy to bees, etc., should carry an epinephrine pen (epi pen), which they should administer if a bite occurs.

Venomous Snakes

Various species of venomous snakes (figure 5.45) are found throughout the United States. Rattlesnakes, copperhead snakes, and others pose little danger to most people if they are left alone in their surroundings. They are generally found away from human populations, so most workers will not often encounter these snakes.

Figure 5.45 Venomous reptiles are found throughout the United States. Each geographic area may have its own set of reptiles that may be hazardous. This is an eastern diamondback rattlesnake. Credit: Pixabay CC0.

Occasionally a farmworker may encounter a snake. Work in seldom-used barns, along fences, and near woodlots can bring the worker a surprise encounter with a snake. Quick identification of the snake as venomous or harmless is necessary.

Venomous snakes have an angular head with a pit in front of the eyes. If such a snake is encountered:

- Slowly back away from the snake.
- Make no sudden or threatening moves.
- Report the incident to others who may have to work in the same area.

If a snake bite occurs, the following steps can prevent the wound from becoming more serious:

- Allow the bite to bleed freely for 15–30 seconds.
- Clean and disinfect the area.
- Stay calm.
- Get assistance to travel to emergency medical care.

Be aware of snake habitats and watch movements carefully.

Insects and snakes are found in fields and barns.

Rabies

Rabies is a viral disease of mammals. It is transmitted through the bite of an infected animal. Most cases of rabies come from wild animals such as raccoons (figure 5.46), skunks, bats, and foxes. Cats, cattle, and dogs can also become infected. Most states require vaccination against rabies for pet dogs and cats.

Rabid animals appear to be confused, paralyzed, excitable, and frothing from the mouth.

The best way to prevent rabies is to avoid animals showing strange behavior. Report animals to authorities.

If bitten by an animal suspected of having rabies, seek medical treatment quickly. A helper should kill the animal, handle the carcass with disposable gloves, and submit it for post-mortem testing.

Figure 5.46 Raccoons are common carriers of rabies. If you find these animals acting abnormally around people, be alert for the danger of a rabid animal bite. Credit: Pixabay CC.

Lyme Disease

Dog ticks and deer ticks often attach themselves to warm-blooded animals and people and feed on their blood. Ticks are often found on people who have been walking in tick-infested areas. Adult ticks wait on host weed species and pass on to warm-blooded hosts as they pass by.

Deer ticks are common in the northeastern United States. Deer ticks may carry Lyme disease and must be removed immediately.

Lyme disease, first reported in Lyme, Connecticut, has spread throughout the Northeast and Upper Midwest. It affects people who have been bitten by a deer tick, but failed to notice the insect attached to their bodies. At least 48 hours of infectious contact will result in the onset of the disease. Lyme disease left untreated can cause a rash and flu-like symptoms followed by loss of coordination, memory loss, irregular heartbeat, and arthritis. Lyme disease is rarely fatal.

Lyme Disease Prevention

Lyme disease is preventable. These considerations will reduce the risk of Lyme disease exposure:

- Wear light-colored clothing when in infested areas (to be able to see ticks).
- Tuck pants into socks to keep ticks out.
- Use an insect repellant approved for tick control to treat clothing before going into woods or fields.
- Avoid weedy, brushy areas that may harbor ticks.
- Check for ticks after returning home.

Lyme disease is a concern, but should not keep anyone from enjoying walking or working in fields and woodlands or from hunting or fishing.

If anyone suspects they are infected with Lyme disease, they should consult a physician immediately. A blood test can help confirm a diagnosis. Antibiotics are used to treat Lyme disease.

Hunters who bag a deer should take precautions to avoid becoming infected. They should inspect themselves after processing the deer.

DEET[8]

Repellents containing the active ingredient DEET are effective in repelling mosquitoes, biting flies, chiggers, fleas, and ticks. Products containing DEET range in concentration from 4% to 100%. Most adults find adequate protection with products containing 10% to 35% DEET.

The American Academy of Pediatrics says using DEET on children appears to safe in concentrations from 10% to 30% as long as the products are used according to the directions on the label, which state, "Insect repellants containing DEET with a concentration of 10 percent appear to be as safe as products with a concentration of 30 percent when used according to the directions on the product labels."

Products containing higher concentrations of DEET do not indicate better protection, but the protection will last longer. These products are better when pests are present in large numbers and when conditions lead to rapid loss of repellent from the skin, such as during significant perspiration. However, DEET efficacy peaks at around 50%, which means products containing more than 50% DEET do not significantly improve protection. Repellants are typically effective for one to five hours, so reapply as needed.

Permethrin

Permethrin is a powerful, fast-acting insecticide and the most effective deterrent for ticks. **Permethrin is applied to clothing, not skin.** It kills ticks and insects that come in contact with treated clothes. Pretreated clothing is also available. Pretreated clothing is a pesticide product, registered with the U.S. Environmental Protection Agency, and has a product label. The effectiveness of both treated and pretreated clothing can last several weeks or longer with proper laundering. Read the product label to use permethrin products safely and effectively.

Follow these guidelines when using permethrin repellents:

- Read the entire product label.
- **Treat clothing only; do not apply to skin.**
- Apply to clothing outdoors in a well-ventilated area protected from the wind.
- Treat only the outer surface of clothing with permethrin repellents. Do not apply to clothing while it is being worn.
- Only spray enough to lightly moisten the outer surface of the fabric, causing a slight color change or darkening; do not saturate clothing.
- Hang treated clothing outdoors and allow it to dry completely before wearing.
- Launder treated clothing separately from other clothing.
- Keep treated clothes in a separate bag when not in use.
- Treat exposed parts of the body (not covered with treated or pretreated clothing) with insect repellents labeled for skin for more complete protection.

Farm Ponds

Farm ponds serve a variety of purposes on the farm, but can also be a danger throughout the year. In summer, ponds are particularly dangerous for children under age 4, who typically have no swimming abilities. The water presents a fun place to play, but children may lose their balance and drown even in shallow water. Close supervision is essential at all times when children are around ponds. Teenagers and farm visitors may also fall victim to farm pond hazards. Nobody should ever swim alone in a farm pond. All farm ponds should be equipped with a rescue station containing a rope long enough to reach across the pond, a life ring, and emergency phone numbers.

[8] DEET and permethrin information adapted from "Using Insect and Tick Repellants Safely." Penn State Extension. **extension.psu.edu/using-insect-and-tick-repellents-safely**

Ponds can be contaminated with fertilizers, pesticides, livestock waste, or algae, making swimming dangerous.

In winter, ice skating, fishing, and playing on and around farm ponds can also be dangerous. Thawed and re-frozen ice can be weak and potentially dangerous. Just because ice is thick does not guarantee its strength. Experts suggest drilling into the ice every 10 feet out from the shore to check ice status. Winter drowning victims must be evaluated for signs of hypothermia and frostbite.

See Farm Pond Safety, **extension.psu.edu/farm-pond-safety**, for more information about all pond hazards.

ACTIVITY 5.1

Weather Hazards

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Learn to be prepared for whatever the weather may bring. Know how to protect against weather-related hazards.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–4 and understands the potential weather-related hazards of farming and how to reduce the risks of suffering from those hazards.

Life Skills: Self-care, preparedness

Tags: Weather, hazards, heat, cold

Time Needed: 30–90 minutes

Materials List:

- computers with internet access
- pens/pencils
- copies of Let's Do It!
- paper

Space: Classroom with internet access

Suggested Group Size: Five to 15 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Identify a person to speak to the group about weather emergencies. Check with the National Weather Service, a local weather company (e.g., AccuWeather), a local university or college, or a local emergency management agency to find an expert who can explain how weather alerts are shared and broadcast.

Introduction: Review the Warm Weather Hazards and Cold Weather Hazards sections of Chapter 5.

Opening Questions: Does your local area sound an alarm if severe weather, such as a tornado, is expected or imminent? If so, do you know what the alarm sounds like? Can you hear it from everywhere on the farm? If not, how do you typically find out about severe weather alerts? If you need a more reliable system, plan it now, *before* your life or property may depend on it.

Do you know someone who's been struck by lightning or sustained damage to a farm, house, or building from a storm? If so, describe for the group what happened.

Do you know someone who has experienced heat exhaustion, heat stroke, or frostbite? Please share the story with the group.

What can we learn from these stories?

LET'S DO IT!

ACTIVITY 5.1

Weather Hazards

1. Match the term to the correct definition:

1. Heat index	a. Condition of overheating whose symptoms include red, hot, dry skin; changes in consciousness; rapid, weak pulse; and rapid, shallow breathing. Can result in death if not treated immediately.
2. Wind chill	b. What the temperature feels like to the human body when relative humidity is combined with the air temperature
3. Heat exhaustion	c. A calculation of wind speed and temperature. Helps you determine when dangerous conditions could lead to frostbite or hypothermia. Accounts for heat loss from the human body to its surroundings.
4. Heat stroke	d. Condition of overheating whose symptoms include cool, moist, pale or flushed skin; headache; nausea; dizziness; weakness; extreme tiredness

2. Is there an emergency action plan in case of high winds or tornado conditions on your family's farm or at the farm where you work? Describe the plan below. If there is no plan in place, ask about formulating one.

____

____

____

____

3. Use the internet to find a heat index chart and answer these questions:

   A. On a 90-degree day with 70% relative humidity, the heat index is ________ degrees.

   B. On a 95-degree day with 50% relative humidity, the heat index is ________ degrees.

   C. On an 85-degree day with 85% relative humidity, the heat index is ________ degrees.

   D. Name three ways you could adapt to the weather on these days.

4. Use the internet to find a wind chill chart and answer these questions:
   A. On a 30-degree day with a 15-mph wind, the temperature will feel like ______ degrees Fahrenheit.
   B. On a 20-degree day with a 15-mph wind, the temperature will feel like ______ degrees Fahrenheit.
   C. On a 30-degree day with a 30-mph wind, the temperature will feel like ______ degrees Fahrenheit.
   D. You are out riding your horse. The temperature is 25 degrees and you are traveling at 12 mph. What is the wind chill factor in degrees Fahrenheit? ______
   E. Name three ways you could adapt to the weather on these days.

   ____

   ____

   ____

5. Listen to a local expert speak to the group about weather emergencies and how weather alerts are shared and broadcast.

Apply: With your family, develop an emergency action plan in case of high winds or tornado conditions.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 5.2

Dust and Respiratory Protection

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Beginner

Ages: 8–18

Learner Outcomes: Learn the importance of using appropriate respiratory protection for various farm chores.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–3 and understands the potential respiratory hazards of farm work. Youth knows the basics of common agriculturally-related lung diseases and how to choose the appropriate respiratory protection for the chore.

Life Skills: Self-care, researching, applying, interviewing, writing

Tags: Dust, mist, fumes, respirator, respiratory protection, lung disease, personal protective equipment, PPE

Time Needed: 60–90 minutes

Materials List:

- computers with Internet access
- copies of Let's Do It!
- pens/pencils
- paper

Space: Classroom with internet access

Suggested Group Size: Five to 15 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Identify one or more farmers who would agree to be interviewed about their experiences with lung ailments common to farmers. Some of the youth may have their own contacts as well.

As an alternative in part 1, identify a respiratory therapist or safety specialist who would speak to your group about lung disease and prevention targeted for farmers and farm workers.

Introduction: See the Respiratory Hazards and Respiratory Protection sections of Chapter 5.

Opening Questions: Do you know someone with lung disease? Describe the accommodations they have to make for their illness.

Do you know an older farmer with lung disease? To what do they attribute their lung disease? What can we learn from their stories?

LET'S DO IT!

ACTIVITY 5.2

Dust and Respiratory Protection

1. Visit the American Lung Association website to learn more about lung disease. Prepare a five-minute presentation for your group on a lung disease common to farmers. As an alternative, invite a respiratory therapist to speak to your group about lung disease and prevention targeted for farmers and farm workers.
2. Visit the website gemplers.com and search for the respiratory protection devices best suited for the following jobs. List the device name, price range, and NIOSH rating.
3. Interview one or more older farmers about their experiences with farmer's lung, organic dust toxicity syndrome (ODTS), and/or silo-filler's disease. Have they typically worn a respirator to sweep, handle hay, mix pesticides, etc? With the farmer's permission, you could summarize the story and lessons learned from it, and write an article to submit to a farming publication in your state.

Reflect: What's the most important step you can take to protect your lungs during farm work?

____

____

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 5.3

Housekeeping and Chemical Safety Around the Farm

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Advanced

Ages: 14–18

Learner Outcomes: Learn the importance of cleanliness and regular maintenance around the farm. Learn how to use common farm chemicals safely.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–3 and can identify common farm housekeeping hazards. Youth knows how to use common farm chemicals safely.

Life Skills: Researching, observing, analyzing, summarizing

Tags: Cleanliness, housekeeping, chemicals, safety, hazards, cleanup

Time Needed: 60–90 minutes

Materials List:

- computers with internet access
- copies of Let's Do It!
- pens/pencils
- paper

Space: Farm shop or classroom with internet access; farm for surveys

Suggested Group Size: ~five people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Identify one or more farms where the youth can conduct a housekeeping and an agricultural chemicals inspection.

Introduction: See the Farmstead Chemicals and Housekeeping sections of Chapter 5. Also review the Personal Protective Equipment section of Chapter 1 and Activity 1.5, Personal Protective Equipment.

Opening Questions: If you know anyone who has been injured in a farm incident related to poor housekeeping, tell that story to the group. How could the injury have been prevented?

LET'S DO IT!

ACTIVITY 5.3

Housekeeping and Chemical Safety Around the Farm

1. Survey a farm shop and list housekeeping items that you judge to be potentially hazardous. Alternatively, you might survey your school's agricultural shop or industrial technology shop, with the instructor's permission.
2. Make an agricultural chemical inspection of a farm with the owner's permission. List all the chemicals you find and the signal words on the labels. Include animal medicines. DO NOT HANDLE CONTAINERS WITH MATERIAL SPILLED OVER THE OUTSIDE OF THEM. Use the internet to look up the purpose of any chemicals you don't recognize.
3. Use the internet to find out how farm workers should clean up an oil spill in the farm shop. Write out the procedure in outline form. Then, look for the procedures for cleaning up an antifreeze spill and a fuel spill. Summarize any differences among these three procedures.

Reflect: Summarize two or three key points in handling agricultural chemicals.

Terms and Concept Discovery: Define the following terms in your own words.

Acid:____

____

Base:____

____

Flash point:____________________________________

____

Kindling point:__________________________________

____

Volatility:_____________________________________

____

Learn More: To see another set of suggested chemical safety activities, visit **progressiveag.org**.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 5.4

Electrical and Fire Safety

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Beginning

Ages: 8–18

Learner Outcomes: Learn about safe electricity use on the farm and how to avoid common electrical hazards. Learn about the fire triangle and the classes of fire.

Education Standard(s): **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–7 and understands common electrical hazards on the farm and how to safely work with electrical equipment used in farming. Youth knows the components of the fire triangle and the three classes of fire.

Life Skills: Researching, observing, analyzing, summarizing

Tags: Housekeeping, safety, fire safety, electrical hazards, electricity, fire extinguisher

Time Needed: 60–90 minutes, not including travel to or from farm

Materials List:

- computers with internet access
- copies of Let's Do It!
- pens/pencils
- paper

Space: Farm shop or classroom with internet access; farm for surveys

Suggested Group Size: Five to 10 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Identify one or more farms where the youth can conduct an electrical safety survey and a fire extinguisher survey.

Variation: Arrange for a firefighter to visit the group and discuss fire safety and demonstrate fire extinguisher use. They could also discuss approved fuel containers.

Introduction: See the Housekeeping, Fire Safety, and Electrical Hazards sections of Chapter 5.

Opening Questions: If anyone has first-hand experience with a fire that has gotten out of control, please share that with the group. Describe any attempts to control the fire.

LET'S DO IT!

ACTIVITY 5.4

Electrical and Fire Safety

1. With permission of the farmer or owner, conduct an electrical safety survey of a farm in your area. The following chart will get you started, but you can also add any other electrical hazards you find or know about, such as a fuse that repeatedly blows out or trips, or a light that flickers.

Items to look for	Where found
Missing distribution panel or fuse box cover	
Broken or damaged electrical equipment	
Extension cord used as permanent wiring	
Damaged extension cord	
Low-hanging power line	

2. Conduct a survey of a local farm and note the placement, condition, and number of fire extinguishers on tractors and other machinery and in the buildings. Look for an inspection date. Are the extinguishers current on their inspections? Report your findings using a chart or a map.

3. Research ground fault circuit interrupters (GFCIs). How does this device work and where should it be used?

4. Learn about the correct method of using a fire blanket to put out a kitchen fire, then practice it. How should a fire blanket be used to put out a clothing fire? Practice with a partner.
5. Recite the PASS process for using a fire extinguisher and do a mock demonstration.
6. An electric motor is on fire. Which fire extinguisher should you use and why?

7. Could a couple of shovels full of soil put out a small oil fire in an oil pan? Explain your answer in terms of the fire triangle.

Reflect: What are three important ways you can reduce fire risk on the farm?

Learn More: Listen to a firefighter discuss fire safety and demonstrate fire extinguisher use. You might ask them to discuss approved fuel containers.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

ACTIVITY 5.5

Noise Hazards and Hearing Protection

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Beginning

Ages: 8–18

Learner Outcomes: Learn about common sources of noise on the farm and the kinds of equipment that help protect hearing.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–4 and understands that animals and machinery on farms commonly present noise hazards. Youth understands the options for hearing protection equipment and the importance of using it regularly.

Life Skills: Empathy, measuring, researching, interviewing, summarizing

Tags: Hearing, hearing loss, deafness, personal protective equipment, PPE, noise

Time Needed: 60–90 minutes, not including travel to or from farm

Materials List:

- decibel meter or smartphone with decibel meter app (see below)
- computers with internet access
- copies of Let's Do It!
- pens/pencils
- paper

Space: Farm shop or classroom with internet access; farm

Suggested Group Size: Five to 10 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Obtain or borrow a decibel meter for use in the activity. Instead, you may be able to use this free app from the federal Centers for Disease Control and Prevention: **cdc.gov/niosh/topics/noise/app.html**

Show this video to the youth: **noisyplanet.nidcd.nih.gov/parents/keeping-noise-down-on-the-farm** (video about kids aged 8-12 protecting hearing on farm)

You may also want to identify a farmer who would agree to be interviewed about his or her farm-related hearing loss.

Introduction: See the Noise Hazards and Hearing Protection section of Chapter 5.

Opening Questions: Do you know a farmer who has suffered hearing loss on the job? What kinds of noise were they exposed to regularly? Did they wear any hearing protection? How does hearing loss affect them now?

LET'S DO IT!

ACTIVITY 5.5

Noise Hazards and Hearing Protection

1. Visit this federal Centers for Disease Control and Prevention website **cdc.gov/niosh/mining/content/hlsoundslike.html** to hear what hearing loss sounds like.

2. Use a decibel meter to measure the decibel levels of the following farming operations, or others that are feasible for your group.

   A. tractor motor running

   B. cows mooing at milking time, or pigs squealing

   C. chain saw in use

   D. milk-cooling compressor

   How does each of those sounds compare to table 5.1, Decibel levels of common sounds, and table 5.2, Permissible noise exposures, in Chapter 5? Which ones would require the use of hearing protection?

3. Using a supplies website, such as Gempler's or NASCO, make a list of the various ear-protection devices, their noise reduction rating (NRR), and their costs.

4. Interview at least one farmer about their experience with hearing loss. What kinds of noises were they exposed to regularly? Did they wear any hearing protection? How does hearing loss affect them now?

Reflect: What are three ways you can protect your hearing on the farm?

Learn More: Noise-Induced Hearing Loss in Agriculture. Penn State Extension. **extension.psu.edu/noise-induced-hearing-loss-in-agriculture**

Chapter 6
Working with Livestock

Working with livestock can be fun and rewarding. To observe a litter of piglets being born, to assist with the birth of a dairy calf, or to train a young horse to lead by halter can be very satisfying. Working with animals is a major task in farming.

Working with livestock can also be dangerous. Animals have their own patterns of behavior. Understanding animal behavior is important to working safely with. This section discusses ways to safely work with livestock.

Working with Livestock: Enriching but Potentially Dangerous

Farm youth learn to work at an early age. Small children are routinely assigned to feed calves, heifers, pigs, and poultry. Junior livestock programs in rural counties help youth learn how to feed, care for, and market their animal project. Responsibility, confidence, and animal handling skills are gained by doing this work.

Injury statistics show working with livestock is also hazardous. Here are recent numbers from the National Children's Center for Rural and Agricultural Health and Safety:

- Every three days, a child dies in an agriculture-related incident.
- Every day, about 33 children, or over 12,000 per year, are injured in agriculture-related incidents.
- Numerous injury surveys from past years indicate animals are a leading cause of nonfatal injuries to youth on farms.

Working with livestock exposes the youthful farmworker to an increased risk of injury. Livestock hazards are recognized as part of the Hazardous Occupations Order in Agriculture (HOOA). In these regulations, youth under age 16 are prohibited from working in a yard, pen, or stall with:

- cows with newborn calves (Figure 6.1)
- bulls, boars, or stud horses kept for breeding purposes
- sows with nursing pigs

Not all livestock jobs are hazardous. Caring for poultry, milking cows, cleaning barns and equipment storage buildings, and riding, driving, or exercising horses are considered acceptable tasks, depending on the age and experience of the youth. Adult supervision of small children doing these tasks is recommended under the Ag Youth Work Guidelines from the National Children's Center for Rural and Agricultural Health and Safety (**marshfieldresearch.org/nccrahs/agricultural-youth-work-guidelines**).

If youth are working with livestock, the expectation is they will be trained and supervised by an experienced person to safely do the work.

Figure 6.1 A cow with a young calf is usually protective of her offspring. Credit: Pixabay CC0.

Livestock are linked to one in every five farm injuries.

Warning signs of animal fear and/or aggression include:

If an animal exhibits one or more of these signs, get out of its way immediately:

- raised or pinned ears
- raised tail or hair on the back
- bared teeth
- snorting
- pawing at the ground

Animal Behavior Facts

Animals have patterns of behavior. Some behaviors are instinctive and others develop from habit. Cattle are called creatures of habit. For example, cows line up at the holding pen at milking time. The sound of feeding equipment starting will bring animals to the feeder.

Understanding animal behavior is the first step in working safely with animals. Here are some animal behavior facts.

- No matter how tame animals seem, they still have territorial instincts. Both males and females can be very protective of their area. They may challenge an intruder that comes into their space.
- Animals become acclimated to particular locations, sights, smells, and sounds. When moved to new and strange surroundings, livestock will react tentatively.
- Female livestock are maternal. They will try to protect their young from danger.
- Older male animals are more aggressive and unpredictable. Male hormones cause this. Bulls account for more than half of livestock-related injuries and deaths. Special facilities should house males and

handlers should reduce the amount of time spent in those pens.
- Animals tend to group together for safety. Single animals are more dangerous and difficult to handle.
- Animals tend to follow a leader when being moved. If no animal makes a move, the group tends not to move.

Roy's mother thought it was cute to teach the feeder calf to butt her hand with its head. When the FFA steer weighed 1,200 pounds, the animal still liked to butt her hand, but that wasn't fun any longer.

Moving Animals

Getting livestock to move is a matter of understanding the animal's "flight zone" and "point of balance." Animals will move easily if these two concepts are used with calm movement and the least noise possible.

Animals have a personal space just like people. The size of that space depends upon the animal's tameness, the excitement level, and the angle at which a handler approaches the animal. If the handler moves into the animal's *flight zone* (figure 6.2), the animal will turn to move away from them. If the handler moves outside the flight zone, the animal will turn to look at them. If the animal feels trapped in a corner and has limited vision, the animal may kick to warn the handler to stay away.

The animal will move according to the handler's position at its *point of balance* (figure 6.3). The point of balance is the animal's shoulder. All species of animals will move forward if a person is behind the point of balance. If a person is in front of the point of balance, all animals will stop, back up, or turn away, depending on the person's position relative to the animal's flight zone.

Using the point of balance works for moving larger groups of animals as well. Use this understanding to move animals without prods, "hot-shots," or shouting and screaming. People are smarter than animals and should use their thinking skills when working with livestock. *Hint:* Watch a livestock show. Leaders will move in front and to the back of the point of balance to move their animal easily.

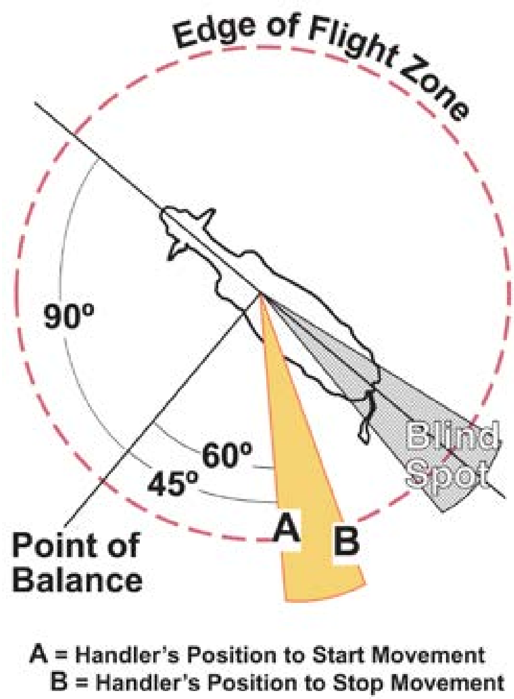

Figure 6.2 Flight zone. Animals have a "personal" space. That space varies with how tame or wild the animal is. An excited animal has a larger flight zone. When you enter the flight zone, livestock turn to move away. If you surprise an animal by entering the blind spot of the flight zone from the rear, you may be kicked. Credit: J. Mathison.

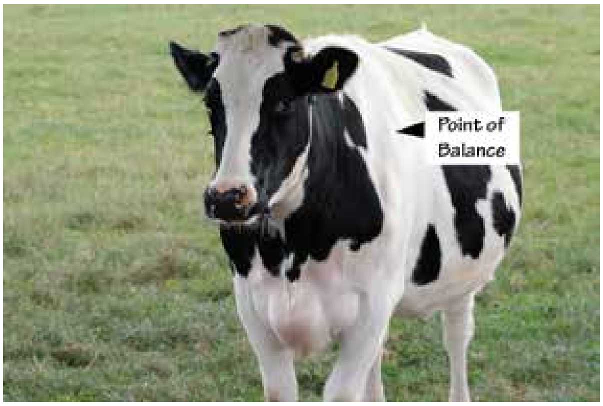

Figure 6.3 The animal's shoulder is the point of balance for movement. Stand behind the shoulder, the animal moves forward. Stand in front of the shoulder, the animal stops moving forward. Credit: Pixabay CC0.

Understand Livestock Behavior to Minimize Difficulties

Animals have a zone of comfort within which they behave normally. Intrusion into that space will cause the animals to move to re-establish the comfort zone. For example, livestock create well-worn paths between pastures and buildings, and water troughs and feed bunks. Animals may challenge an intruder who comes into their space. Forcible removal from this known territory tends to disturb the animal.

Livestock respond best to routine. To reduce skittishness, establish a routine for the animals to follow. For example, feeding should occur at around the same time each day. Livestock should get used to seeing the same people at the same time.

Most livestock have poor depth perception, so they have difficulty judging distances. They cannot see behind them, so they will turn to keep a handler or perceived danger within their sight. Livestock see objects in black and white, not in color. Their vision limitations can make an animal balk if a shadow is cast across its path. Sheep are considered to be color blind, but have no depth perception problems. Instead, they have problems picking out small details, such as the open space created by a partially opened gate.

Animals are frightened or spooked easily by noise and will always try to move away from the direction or source of the noise. Their limited eyesight may cause them to crash against or through any objects, including people, in their path of escape. Move animals with a minimum of noise and confusion. Cattle are very sensitive to loud noises and can hear sounds humans cannot. Therefore, it is essential no one yells when working with livestock. High frequency sounds can harm their ears.

When working with animals it is also best to have a plan of action. Know what needs to be done, how to do it, what could possibly go wrong, and how to respond in case of a problem. For example, know the plan of action before stepping foot in into a corral with a mother and her newborn. Always plan an escape route ahead of time to decrease the chance of injury.

When taking a closer look at livestock, make sure to announce your presence before getting too close. If livestock are not aware of people entering their pen, they can be frightened easily. Talk to the animal quietly while entering the pen. This will reduce any skittish behavior.

An animal is often characterized as being "stubborn" because it has balked or refused to enter an area. Once this has happened, the animal is likely to refuse the next several times as well and it may get a little more excited and dangerous with each refusal. Because of this, take time to plan the process of moving the animals before the first attempt. Plan the movement route, observe what areas may have shadows or obstructions, and inform all helpers of what needs to be accomplished in moving the animals. Many farmworkers are tempted to "try it" before thinking and end up in a real battle with the animal. This may lead to an injury.

Common "People Problems" in Handling Livestock

Recognize people's actions may be the reason for difficulty in moving or working with animals:

- haste, impatience, anger at another person or object or the animal, or a preoccupied mind
- prodding an animal with no place for the animal to go
- improper lifting of young animals
- horseplay
- looping lead straps around the handler's hand
- attempting a task without enough help
- not wearing personal protective equipment, including steel-toed, non-skid safety shoes and gloves, and helmets for riding

By understanding the animal, providing safe facilities, using proper personal protective equipment, and working with the animal's natural instincts, injuries and fatalities involving livestock can be reduced.

Precautions to Take

Livestock chores are less hazardous if handlers understand the animal's behavior. These are precautions to follow to ensure the work is a pleasant experience, free of injury.

- Plan ahead to allow plenty of time to move animals so there is no need to hurry. Do not try to manhandle animals when angry.
- Plan for an escape route when working with livestock. Pens and corrals should have people pass-through openings for escape purposes.
- Wear steel-toed, nonskid shoes—not sandals or sneakers—when working with livestock.
- Avoid the hind legs of animals.
- Use squeeze chutes to hold animals securely for veterinary procedures.
- Approach livestock from the front or sides to stay in their line of sight.
- Move cattle in well-lighted areas, not shadowy places.
- Avoid quick movements and loud noises.
- Be patient and calm.
- Keep animal-handling facilities in good repair with no sharp projections.
- Ask for help to move or work with an animal if the animal is excited or nervous.
- If the animal becomes nervous and agitated, wait 30 minutes before attempting to work with the animal again.
- Handlers should avoid touching their face when working with livestock. Wash hands thoroughly when finished handling livestock and before eating or drinking.

When working with animals, always have an escape route. Do not corner the animal.

Livestock Facility Design

Designing livestock facilities to ensure the safety of both animals and people can minimize animal skittishness. Many injuries come from poor facilities and equipment. Good facilities have concrete flooring with a grooved surface, correct drainage, sturdy fencing, adequate lighting, and all sharp objects removed to ease animal handling. Well-designed facilities provide a means of controlling animals while allowing easy access for feeding and cleaning, all in a safe environment.

Summary

When working with livestock stay calm and use a quiet voice, avoid the animals' blind spots, and announce your presence before getting near the animal. Caretakers should keep a regular routine for animal care and have a plan of action in case a problem arises when working with livestock. Keep in mind animals have territorial instincts and could be dangerous for the caretaker.

Finally, respect the livestock and do not fear them. The livestock are there to provide food and profit. Get to know the animals and understand their behavior to properly take care of them. Respect their size, capability, and strength and be alert at all times.

ACTIVITY 6.1

Livestock Behavior and Handling

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Beginning

Ages: 8–18

Learner Outcomes: Learn how common livestock behavior can be dangerous to people. Learn to identify warning signs of territoriality in livestock. Learn to use animals' natural tendencies and senses to make handling them easier. Learn how to stay healthy while working around livestock.

Education Standards: **AS.02.** Utilize best-practice protocols based upon animal behaviors for animal husbandry and welfare.

CRP.01. Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

Success Indicators: Youth completes parts 1–9 and understands livestock flight zones and point of balance and how to use these natural tendencies to their advantage when working with livestock. Youth understands how to stay safe while working with livestock.

Life Skills: Personal safety, animal handling, sanitation,

Tags: Flight zone, point of balance, livestock, personal safety, health, diseases

Time Needed: 90–120 minutes, not including travel to or from the farm

Materials List:

- livestock with lead ropes and halters
- computers with internet access
- copies of Let's Do It!
- pens/pencils
- paper
- poster boards

Space: Classroom with internet access; farmyard

Suggested Group Size: Five to 10 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Identify a farm where the youth could conduct an animal handling facilities safety tour.

Identify a few different animals the students could use for parts 3 and 4. Could the youth do these parts on the same farm where they conduct the animal handling facilities safety tour?

Introduction: Review Chapter 6.

Opening Questions: Most animals are territorial. What does this mean? Think of incidences you have observed in which an animal exhibited territorial behavior. How did they look or behave? How did you and/or the other people present behave? Discuss a few of the incidences as a group. Has anyone ever seen someone injured by a territorial animal? What happened?

LET'S DO IT!

ACTIVITY 6.1

Livestock Behavior and Handling

1. Use the internet to find videos of different kinds of aggressive farm animals. Make notes about common warning signs.

   ____
   ____
   ____
   ____
   ____

2. Inspect a farm's facilities for handling livestock. Note the positions of pass-through gates. Inspect all animal pens and alleyways for sharp obstructions such as nails or sheet metal, broken boards, and damaged gates. Note your findings for the farmer. See if you could work with the farmer to fix these items.

   ____
   ____
   ____
   ____
   ____

3. (Skip this part if you've already worked extensively with livestock for shows.) Ask a friend who has a halter-broke animal to show you how easily an animal will move backward or forward based on a person's slight movement front or back of the point of balance.
4. Practice moving a small group of animals slowly and quietly using knowledge of the flight zone and point of balance.
5. Make a poster showing the flight zone of the kind of livestock you are most likely to work with to educate others about how to move safely around these animals.

6. Explain why it's safer to stay close to an animal while you work with it, rather than several feet away.

____

____

____

7. Draw a picture showing how an animal's lead rope should be held to keep the handler safe.

8. Name two things you can do to help you stay healthy while working with livestock.

____

____

9. Which of the following is not a disease you can get from animals (circle the correct answer): a. rabies; b. ringworm; c. epilepsy; d. salmonella

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More: Malone, B., and V. Schwartz. Putting Science into Animal Science Projects. **extension.purdue.edu/4h/Documents/Volunteer%20Resources/Livestock%20 Volunteers/Lesson%206%20Moving%20Lifestock%20Safely.pdf**

To see another set of suggested animal safety activities, see the Progressive Agriculture Foundation, educational resources, **progressiveag.org**.

Chapter 7
Emergency Planning

Note to leaders: Use discretion in covering this material, based on the age and maturity of the youth. Some of this material is too advanced for many youth aged 8–13.

Knowledge of first aid and rescue tactics is important for everyone. Risk can be reduced by careful planning and safe work habits, but injuries can still occur. Know what to do if an injury occurs at work and on the farm.

This chapter discusses emergency planning and preparation, first aid, and rescue basics, but professional emergency rescue workers have far more training. Sometimes the best help in an emergency is to summon trained professionals.

The goal of the person first on the scene of a farm accident is to alert emergency medical services (EMS) and keep the victim alive until they arrive. All family members and full-time farmworkers should receive training in first aid and cardiopulmonary resuscitation (CPR).

Important: Enroll in a CPR and first-aid course and keep skills current. Contact the American Red Cross, American Heart Association, or local EMS service.

Planning

Some things to consider when planning for emergencies:

- Monitor a NOAA weather radio and/or cellphone weather alerts when severe weather is expected.
- Listen for local warning sirens, such as for tornadoes. Make certain they can be heard.
- Create a map of the farm, including buildings, access roads, barriers, livestock locations, hazardous substance storage, and electrical, water, and gas shutoffs. For more details, see Penn State Extension's ReadyAG Workbook, p. 67 (see Resources at end of chapter).
- Inventory the farm, including animals, crops, machinery, and hazardous substances (pesticides, fertilizers, fuels, medicines).
- List emergency numbers by the landline phone and in the cellphones of all workers on the farm (e.g., veterinarian, county extension service, insurance agent).
- Assemble a farm first-aid kit.
- Gather emergency supplies (e.g., sandbags, plastic sheeting/tarps, wire and/or rope, lumber and plywood to protect windows, extra fuel, hand tools, fire extinguishers in all barns and vehicles, extra food for people and livestock, gas-powered generator and extra gasoline)

Communications

There should be a method to contact emergency personnel and other workers from any location on the farm, including distant fields.

If cellphones are used, confirm the signal is sufficient throughout the farm and keep batteries charged. Employees must have all other employees' cellphone numbers stored in their phones.

If two-way radios are used, batteries should be checked daily. All employees must know the correct channel to use and check the radios frequently to ensure they are on the correct channel. Volume must be set appropriately so employees can hear radios, even in noisy areas.

Sometimes, the only option may be to flag down a passing driver and ask them to contact EMS.

Emergency Contacts

In an emergency, a call to 911 or to emergency medical service (EMS) personnel must be made quickly. Telephone numbers should be posted near the phone or stored in everyone's cellphone. Include these numbers:

- fire department
- police department
- ambulance service
- poison control center
- electric and gas companies

Be prepared to give directions to the site of the accident. Many times, people panic and cannot remember their address, phone number, or directions to the farm during a crisis. Have this detailed information posted by the phone with the emergency phone numbers. Employees working in areas without landlines could take a photo of this information and tag it in their cellphone for easy access.

Write down the address and the directions to the farm to read to emergency responders.

Preparations

No one can predict when or where an emergency will occur, but advanced planning can help protect people, animals, and property, and minimize disruption to the farm enterprise.

In addition to proper equipment, a safe work site should include:

- two people trained in CPR and first-aid procedures
- a farm first-aid kit and supplies
- an emergency plan, including easily accessible telephone numbers for services in addition to 911
- a location or site map available for emergency responders. Post prominently on the main barn and/or at the entrance to the farm and provide a copy to local emergency responders.

CPR Training

Cardiopulmonary resuscitation (CPR) is used to provide manual ventilation (air intake) and chest compressions to stimulate the patient's heart and lung operation until medical help arrives or the victim begins to breathe on their own. CPR can help injured victims or people suffering from a heart attack or stroke.

CPR classes are offered by the American Heart Association, the American Red Cross, or local emergency responders in most communities. CPR is best learned in the classroom and with practice under the supervision of a qualified instructor. CPR guidelines change periodically. Once people are trained, they should stay up to date with a periodic refresher class.

First-Aid Kit

General purpose first-aid kits (figure 7-1) are readily available. A small, well-maintained first-aid kit should be placed on every tractor, farm truck, and major piece of equipment. A larger kit should be located in the farm shop or at home. The small kits should contain at a minimum:

- sterile first-aid dressings and compresses of various sizes
- roller bandages
- adhesive tape
- disinfectant soap or wound cleanser
- tweezers
- scissors
- latex gloves
- directions for requesting emergency assistance

First-aid kit signs should be placed on drawers or cabinets to indicate the first-aid kits are stored there. All workers must know where the first-aid kits are located. Be sure to keep kits fully loaded and up to date.

Figure 7.1 A first-aid kit should be kept on all tractors, farm trucks, and major pieces of equipment. Replace items as they are used or expire so that the supplies are always available. Credit: J. Mathison.

Items in a Large Farm First-Aid Kit

- sterile first-aid dressings in sealed envelopes:
- 2-inch square
- 4-inch square
- two trauma dressings
- small, sterile adhesive compresses in sealed envelopes
- roller bandages and 1-inch, 2-inch, and 6-inch cling bandages
- adhesive tape in assorted widths
- triangle bandages
- antiseptic wash
- tongue depressors
- heavy-duty scissors
- tweezers to remove insect stingers or splinters
- splints for broken limbs
- sterile saline solution
- safety pins
- ice packs (chemical ice bags)
- pocket mask for resuscitation
- three small packages of sugar (for individuals with diabetes)
- disposable rubber gloves
- goggles
- emergency blanket
- flashlight
- waterproof matches

Condensed from First-aid kits for production agriculture. (2013). Farm and Ranch eXtension in Safety and Health (FReSH) Community of Practice. Retrieved from **articles.extension.org/pages/66377/first-aid-kits-for-production-agriculture**.

First-Aid Basics for Non-Life-Threatening Injuries

First-aid practices for minor cuts, abrasions, splinters, insect stings, snake bites, and burns are easily completed. First-aid kits will consist of disinfectants, bandages, and light wraps useful until medical help is secured. Be careful to keep dirt out of open wounds and do not apply any ointment or cream to burns.

Sometimes the best help for an injured victim is to seek more help.

Farm Family Emergency Response

A farm family member is often the first person on the accident scene. Fear, panic, crying, and shock can occur. These emotional responses may delay getting help for the victim. Discuss farming hazards, and practice emergency procedures to better handle emergencies.

Discovering a victim of an agricultural accident requires immediate action:

- contact emergency medical services (EMS)
- stabilize the scene
- provide patient care

Activate EMS

The first rule when responding to any emergency is to keep calm. Fear and anxiety are normal reactions when someone else is severely injured. Preparation in advance through planning and training helps responders overcome those emotions and act rationally and effectively.

Act quickly and calmly to determine whether to remain at the site or to seek help. If the injury is potentially life-threatening, or if there is any doubt it could be, call 911 before beginning first aid.

The condition of the victim, hazards at the scene, and the time required to contact EMS are important factors in this decision. For example, if cellphone coverage is unavailable, flag down a passing driver and rely on them to notify EMS, or go to the nearest home to call 911. Timing is crucial because the victim may not be breathing, may not have a pulse, or may be bleeding severely. If breathing stops, irreversible brain damage could occur in 4–6 minutes and the heart may stop beating. So, in the time it takes to notify EMS, the victim could die or suffer permanent brain damage. This drastic outcome may be prevented if CPR or first aid can be administered before leaving to contact EMS.

Every farm should have a site map located at the entrance and/or main barn. Rescue teams can then assess the location and identify potential hazards. Be sure local EMS responders know where the site map is located and/or have a copy of it on file.

After notifying EMS, if the accident is at a remote location, someone may need to be assigned to direct EMS to the site of the emergency so other people can return to the victim.

Before returning to the accident scene, gather materials needed to reach the site or to rescue the victim. Materials might include a tractor, chain, boards, additional first-aid items, etc.

Stabilizing the Scene

Controlling hazards at the scene to prevent injury to rescuers or further harm to the victim is called “stabilizing the scene.” Tractors and machinery can roll further. Fire and explosions can occur. Hazardous materials can spill, or toxic fumes can be present. There may be electrocution danger. Be cautious. Don’t rush to help the victim and become a victim.

While approaching the accident scene, assess the apparent injury to the victim as well as the potential danger to rescuers and the victim. Safety must be the primary concern. If the rescuer is injured, there may be no one left to help, especially if the incident occurs at a remote location and EMS has not been notified. In the decision tree (figure 7-2), the assumption is whatever a first responder decides about the victim also applies to them. So, if the victim is in no further danger, rescuers should not be either.

If the scene cannot be stabilized, but the victim can be safely approached, try to remove them from danger. If a spinal injury is suspected, move them **only if there is imminent danger** of further injury. Moving them could cause paralysis or death. Accidents causing spinal injury include entanglement in farm machinery, entrapment under farm machinery, being thrown from equipment, or falling a long distance. Take time to think about the risk to the victim.

Decisions are important. Read about various situations and enroll in CPR and first-aid classes to increase decision-making skills in emergency events.

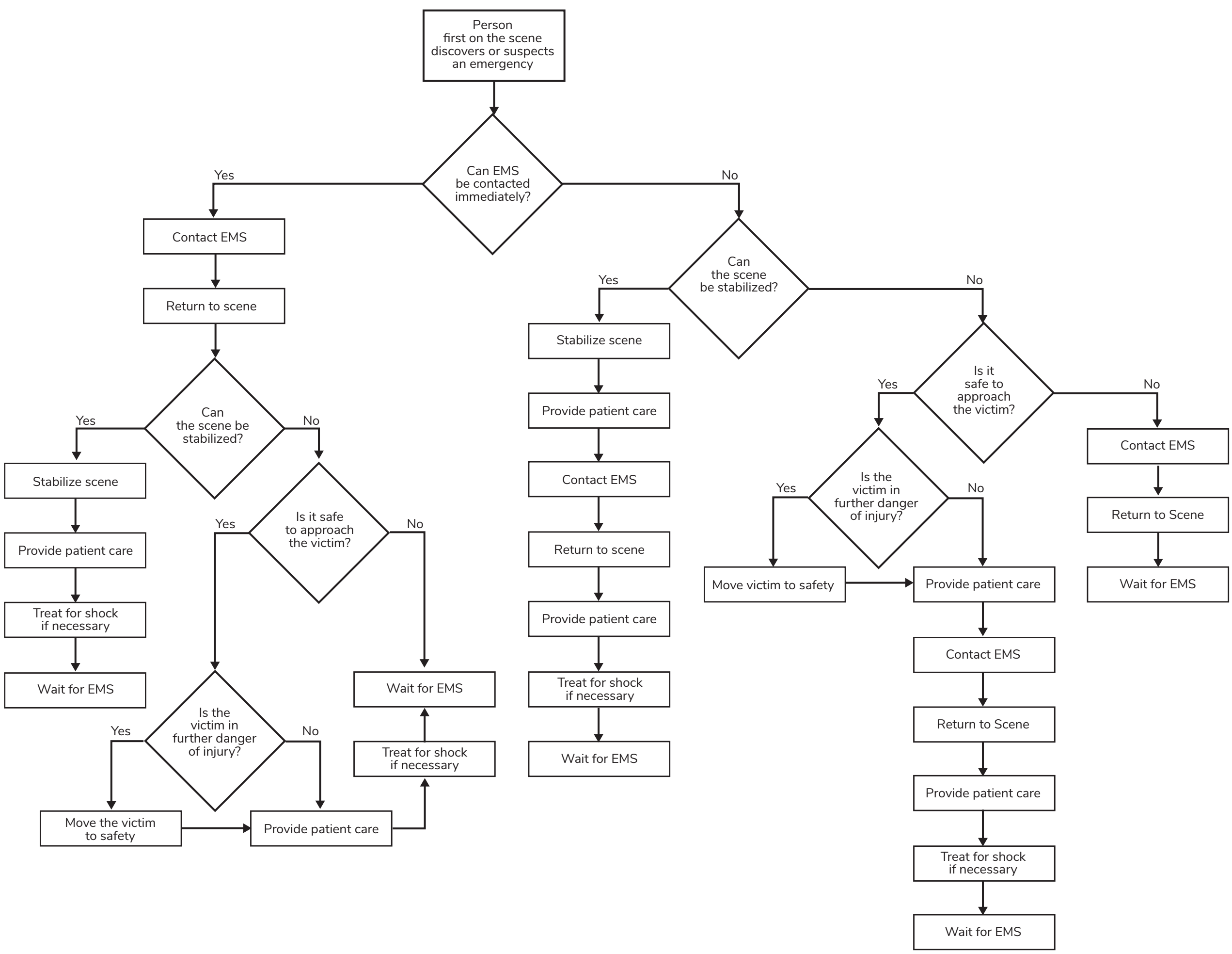

Figure 7.2 Decision tree for general response to farm incidents. Credit: PSU Ag Safety.

Moving a Victim with a Spinal Injury

The spinal column is a bundle of nerves in the center of the back bones, or spine. If a person's injuries result in severe displacement of a vertebrae, the cord can be pinched or cut. All damage to the spinal cord is permanent because nerve tissue cannot heal itself. The result of nerve damage is paralysis or death.

DO NOT move the limbs or body of a victim with a suspected spinal injury unless there is imminent danger of further injury or unless movement is necessary to establish breathing. The victim's body should be stabilized (sandbags are ideal) to prevent any movement of the head, neck, or body. Any movement of a victim with spinal injury may cause paralysis or death.

If the victim must be moved, keep the midline of the body as straight as possible and pull in a direction in a straight line with the victim's spine. Pull the body from the feet or shoulders, using both feet, both shoulders, or both arms pulled over the shoulders. It is also possible to pull the victim by the clothing (figure 7-3). Grab the victim by the collar of the shirt and support the victim's head with the forearms while pulling. The "clothes drag" is preferred because the victim's head is supported while being moved. Do not pull the body sideways.

When providing patient care, rolling the victim over onto their back to clear an airway or evaluate breathing may be necessary. The head, neck, and torso should be moved together so no twisting occurs.

Figure 7.3 "Clothes drag" method for moving a victim. Credit: J. Mathison.

Providing Patient Care

This section discusses the appropriate sequence of decisions and actions referred to by "Provide patient care" in figure 7-2. After completing the sequence, return to figure 7-2 and continue with the decisions and actions following the "Provide patient care" box.

The decisions and actions described here will increase the probability the victim will be alive when EMS arrives.

First establish no one, including the victim, is in further danger. Then, assess the degree of lifesaving emergency care to provide. As part of the assessment, consider whether EMS has been notified. The situation will dictate the amount of patient care to provide before contacting EMS. The following discussion is outlined in figure 7-4; review this decision tree while reading through the section.

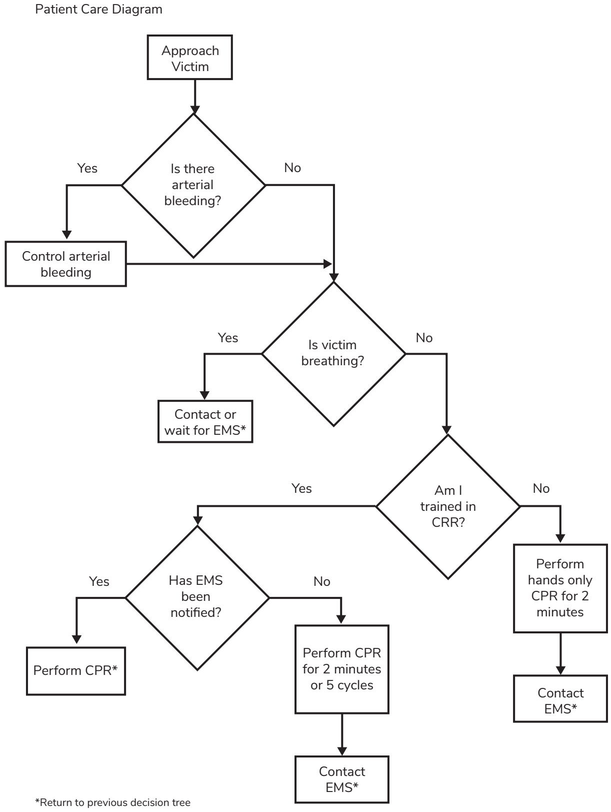

Figure 7.4 Decision tree for providing patient care. Credit: PSU Ag Safety.

As indicated in figure 7-4, the rescuer should first check for and control any arterial bleeding. A victim can bleed to death within minutes or go into shock, so it is important to control arterial bleeding before leaving the scene to contact EMS. Arterial bleeding can usually be identified as bright red blood squirting from an open wound, as opposed to a constant flow or ooze of blood.

Control arterial bleeding by placing a cloth, if readily available, over the wound and applying direct pressure with the palm of the hand (figures 7-5 and 7-6). Because sterile bandages usually are not available at the scene, improvise with clothing, rags, or old sacks. Infection from dirty materials will be treated at a hospital if the victim survives.

Figure 7.5 Stop arterial bleeding by pressing a cloth directly over the wound and applying pressure with the palm of your hand. Credit: J. Mathison.

Figure 7.6 Severed arteries spurt blood. In this case, the artery of the upper arm must be pressed firmly against the upper arm bone to stop bleeding. Credit: J. Mathison.

For more information about stopping arterial bleeding, see this from Harvard Health: **tinyurl.com/yc4kvz3b**

Infectious diseases can be readily transmitted by body fluids, especially blood. Consider including goggles or glasses and rubber or latex gloves in first-aid kits. Be careful of blood squirting in eyes or mouth. Be sure to thoroughly wash hands or other exposed parts of the body.

Once arterial bleeding has been addressed, the next step is to determine whether the victim is breathing. To check for breathing, look for chest movement, listen for escaping air, and feel for airflow. If there is a potential for spinal injury, check breathing without moving the victim.

If the victim is lying face down, chest expansion is not evident, and breathing cannot be evaluated, there is no choice but to roll the victim over. Even if there is a chance spinal injury has occurred, the victim must be rolled over. Breathing takes precedence over other potential injuries, because without air the victim will die or suffer permanent brain damage within four to six minutes. The box, "Moving a Victim with a Spinal Injury" discusses how to roll a victim over.

If the victim is not breathing, the next action depends on whether the rescuer knows CPR. If they know CPR, EMS has not been notified, and the victim's condition indicates mouth-to-mouth breathing or chest compressions are needed, perform this procedure for two minutes only, then contact EMS. If EMS has been notified, the rescuer should perform CPR until EMS arrives or until they are exhausted.

If the rescuer does not know CPR or their training is outdated, do hands-only CPR if it is needed. Push hard and fast in the center of the chest at the rate of 100–120 beats per minute. Do this for two minutes and then notify EMS. Once EMS has been contacted, continue with hands-only CPR until EMS arrives or the victim begins breathing on their own.

For more information on CPR:

- Cardiopulmonary resuscitation (CPR): First aid. Mayo Clinic. **mayoclinic.org/first-aid/first-aid-cpr/basics/art-20056600**
- Hands-only CPR. American Heart Association. **cpr.heart.org/en/cpr-courses-and-kits/hands-only-cpr**

Learning CPR can save lives!

Shock[9]

A person in shock has insufficient blood circulating to their vital organs. Shock may result from severe burns, wounds, or infection; heatstroke; heart attack; allergic reaction; poisoning; or other causes. Shock is usually caused by the external or internal loss of large quantities of blood or other body fluids. Shock is different from simple fainting and from the natural anxiety occurring with injury.

A shock victim may have:

- pale, cool, clammy skin
- enlarged pupils
- nausea or vomiting
- rapid pulse and breathing
- weakness or fatigue
- dizziness or fainting
- anxiety or agitation.

If a victim is in shock:

1. Call 911, if possible.
2. Lay the victim down with legs and feet slightly elevated, unless this may cause pain or further injury.
3. Keep the victim still and don't move them unless necessary.
4. Loosen tight clothing and, if needed and available, cover the victim with a blanket.
5. Give no food or drink.
6. If the victim is having an allergic reaction, and an EpiPen is available, use it according to its instructions.
7. Control bleeding, if necessary.
8. If the victim vomits or bleeds from the mouth, turn him or her onto a side to prevent choking, unless a spinal injury is suspected.
9. If the victim is not breathing, refer to figure 7.4 for further direction.
10. If 911 has been called, wait for EMS. If EMS has not been called, do so now.

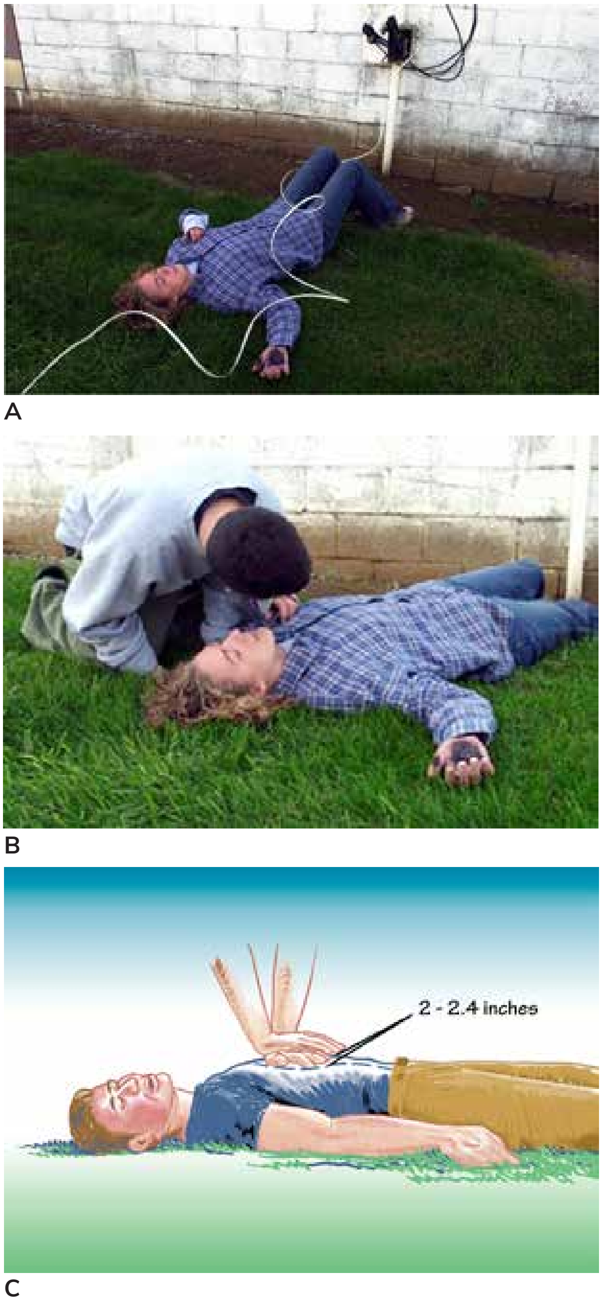

Figure 7.7a–c A farm emergency has occurred. You approach the victim to render first aid. What must you do? First activate emergency medical services, if possible. In this case (a) you must be sure that you are not going to be electrocuted. Turn off the power at the main power switch. If you don't know how to do that, do not touch the victim. If you can disconnect the current, follow the patient care diagram in figure 7.4, first checking for and controlling arterial bleeding, then checking for breathing (b), and then possibly performing CPR (c) to the extent of your training. Credit: PSU Ag Safety.

[9] Adapted from Mayo Clinic Staff, 2017, Shock: First Aid. **mayoclinic.org/first-aid/first-aid-shock/basics/art-20056620**

Biosecurity

Diseases of livestock may impact food safety, personal safety, and/or economic concerns.

As herd sizes increase and as animals are placed in more intensive housing, infectious diseases may enter and spread throughout the herd. Relatively small herds with no or minimal animal additions and good animal comfort frequently have a lower prevalence of infectious disease.

Biosecurity includes a set of practices used to prevent the introduction of infectious organisms to a herd or flock, and to limit transmission between animals.

Biocontainment is the series of management practices preventing the spread of infectious agents between animals on a farm or off the farm.

See **extension.psu.edu/biosecurity-a-practical-approach** for information about isolation, resistance, and sanitation used in biosecurity and biocontainment.

Developing a Biosecurity Plan

Biosecurity planning starts with a review of the risk areas present on a farm. Next, comes risk management, in which a preventive plan is developed and implemented. Finally, all members of the farm team—everyone from suppliers to hourly employees and family members—must understand the plan and cooperate to implement it. For more details, see Penn State Extension's ReadyAG Workbook (see References and Resources at end of chapter).

Resources

Ag Safety and Health. **ag-safety.extension.org**

American Heart Association. Hands-only CPR. **cpr.heart.org/en/cpr-courses-and-kits/hands-only-cpr**

Harvard Health Publishing. Emergencies and First Aid—Direct Pressure to Stop Bleeding. **health.harvard.edu/staying-healthy/emergencies-and-first-aid-direct-pressure-to-stop-bleeding**

Mayo Clinic. Cardiopulmonary resuscitation (CPR): First aid. **mayoclinic.org/first-aid/first-aid-cpr/basics/art-20056600**

McNeil & Co., Farmedic. First on the Scene. **mcneilandcompany.com/farmedic/courses/first-on-the-scene/**

National Children's Center for Rural and Agricultural Health and Safety. Integrating Safety into Agritourism. **safeagritourism.org/walkthroughs/emergency-prep-planning/walkthrough-3-first-aid-kit**

Penn State Extension. Biosecurity—A Practical Approach. **extension.psu.edu/biosecurity-a-practical-approach**

Penn State Extension. Ready AG Workbook. Disaster and defense preparedness for production agriculture. **extension.psu.edu/readyag-workbook**

ACTIVITY 7.1

Farm Emergency Response

LEADER NOTES

Review the Note to Leaders at the front of the book before engaging youth in these activities.

Skill Level: Beginner to Advanced

Ages: 8–18 (Some activities may be inappropriate for children at the younger end of this range. Use your judgment.)

Learner Outcomes: Learn how to prepare for farm emergencies.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CRP.08. Utilize critical thinking to make sense of problems and persevere in solving them.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–8 and takes steps to improve farm emergency preparedness.

Life Skills: Emergency preparedness, self-confidence

Tags: Farm emergency, health, safety, emergency response, farm safety, emergency preparedness

Time Needed: 1–4 hours. Activities can be done separately on different days. You might choose only a few activities from those listed below.

Materials List:

- copies of Let's Do It!
- pens/pencils
- computer(s) with internet connectivity

Space: Farm; classroom or other indoor space

Suggested Group Size: One to eight people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange to have someone from your local EMS agency talk to the group and review hands-only CPR and non-life-threatening first aid. Ask them to show the youth how to do the clothes-drag method of moving a victim.

Sketch out a simulated farm emergency that you could role play in part 7 below. Briefly describe the emergency and any complicating factors, etc.

Introduction: Review Chapter 7, Emergency Planning

Opening Questions:

Have you ever have had to respond to an emergency situation when you were by yourself with no one else around? Once the emergency was over, do you think you did everything correctly? How could you have been better prepared?

LET'S DO IT!

ACTIVITY 7.1

Farm Emergency Response

1. Place phone numbers and addresses of all farm locations in every building, near every phone, and in every piece of machinery.
2. Develop a check-in procedure for people working alone or in remote areas. If the person is not heard from within the time expected, someone should check on them.
3. Work with local emergency personnel to create a farm emergency plan that identifies potential hazards and resources that could help in their response. Penn State Extension's ReadyAG Workbook, page 67 (see Resources at end of activity) is helpful for this.
4. Determine whether your farm is correctly located on Google Maps and/or Waze. Sometimes locations are inaccurate for rural areas. If it's incorrectly located, follow the simple directions online to correct it. This step will allow first responders to find you in a hurry.
5. Organize a day on the farm when everyone—family members over 10 years of age and all employees—can learn and practice how to shut off every engine or motor in the event of an emergency. Everyone should also learn how to shut off main water, gas, and electric valves/flows.
6. Ask your local EMS agency to send a representative to talk to your group and review hands-only CPR and non-life-threatening first aid. Ask them to show you how to do the clothes-drag method of moving a victim.
7. Hold a practice session for calling emergency responders. An adult can role-play the 911 operator. Note any special access requirements, like four-wheel drive, or any potential obstacles in reaching a remote location, such as a bridge with a weight limitation.

Reflect: Name three ways the farm where you live and/or work is safer after the completion of these activities.

1. ____

2. ____

3. ____

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More:

Ag Safety and Health. **ag-safety.extension.org**

McNeil & Co., Farmedic. First on the Scene. **mcneilandcompany.com/farmedic/courses/first-on-the-scene**

National Children's Center for Rural and Agricultural Health and Safety. Integrating Safety into Agritourism. **safeagritourism.org/walkthroughs/emergency-prep-planning/walkthrough-3-first-aid-kit**

Penn State Extension. Biosecurity—A Practical Approach. **extension.psu.edu/biosecurity-a-practical-approach**

Penn State Extension. Ready AG Workbook. Disaster and defense preparedness for production agriculture. **extension.psu.edu/readyag-workbook**

ACTIVITY 7.2

Emergency Medical Preparedness

LEADER NOTES

Skill Level: Beginner to Advanced

Ages: 8–18 (Some activities may be inappropriate for children at the younger end of this range. Use your judgment.)

Learner Outcomes: Learn how to prepare for farm emergency situations. Understand the basics of how to respond to farm injury emergencies.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CRP.02. Apply appropriate academic and technical skills.

CRP.04. Communicate clearly, effectively, and with reason.

CRP.08. Utilize critical thinking to make sense of problems and persevere in solving them.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in Agriculture, Food, and Natural Resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–5 below and can explain and perform at least some of the basic steps involved in farm emergency medical response.

Life Skills: CPR, first aid, emergency preparedness, self confidence

Tags: Farm emergency, health, safety, emergency response, first aid, CPR, farm safety

Time Needed: 2–10 hours, depending on the training(s) being pursued

Materials List:

- computer(s) with internet connectivity
- copies of Let's Do It!
- pens/pencils
- first-aid kit(s) and/or kit supplies

Space: Farm; classroom or other indoor space

Suggested Group Size: One to eight people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Explore local options for CPR and/or first-aid courses.

Introduction: Review Chapter 7, Emergency Planning.

Opening Questions: Share and discuss the farm emergency stories you've heard or witnessed, including rescue and response efforts. How might the outcomes have been different if the person(s) first on the scene were better trained for the emergency?

LET'S DO IT!

ACTIVITY 7.2

Emergency Medical Preparedness

1. Conduct a survey to identify the locations of all first-aid kits on the farm where you live and/or work. Check barns, farm shops, tractors, trucks, and other major pieces of machinery. Assemble or buy kits as needed. Use the lists in Chapter 7 to determine what supplies you need. Check existing kits for items that have expired and need to be replaced. Make sure that each kit stored in a drawer or cabinet has a sign marking its location. This advance planning could save someone's life or limb.
2. Survey all people over age 10 on the farm where you live and/or work to determine how many have been trained in first aid and CPR. Make a table of your findings to summarize the various kinds of training.
3. Individually or as a group, complete a CPR and/or first-aid course offered by a local agency such as the American Heart Association or the American Red Cross. Encourage others from the farm to attend with you. If you or others have already received appropriate training, sign up for a refresher course. A lifeguard certification program is another option that would give you the same skills, and also make you eligible for another cool summer job. Some fire departments offer a junior volunteer program in which participants learn basic relevant skills.
4. Many schools, shopping centers, and houses of worship now have automated external defibrillators (AEDs) to use if someone has a heart attack. Learn more about these devices and how they work.
5. Learn about pressure points used to stop arterial bleeding. Post a drawing of the body's pressure points in the farm shop.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More:

American Heart Association. Hands-only CPR. **cpr.heart.org/en/cpr-courses-and-kits/hands-only-cpr**

Harvard Health Publishing. Emergencies and First Aid—Direct Pressure to Stop Bleeding. **health.harvard.edu/staying-healthy/emergencies-and-first-aid-direct-pressure-to-stop-bleeding**

Mayo Clinic. Cardiopulmonary resuscitation (CPR): First aid. **mayoclinic.org/first-aid/first-aid-cpr/basics/art-20056600**

McNeil & Co., Farmedic. First on the Scene. **mcneilandcompany.com/farmedic/courses/first-on-the-scene**

National Children's Center for Rural and Agricultural Health and Safety. Integrating Safety into Agritourism. **safeagritourism.org/walkthroughs/emergency-prep-planning/walkthrough-3-first-aid-kit**

Chapter 8 Confined Spaces

There are many examples of confined-space work areas on farms. Farmers may consider silos, manure pits, and grain bins as the only confined spaces on their farms. Trenches, grain dryers, milk tanks, liquid manure spreaders, petroleum tanks, well shafts, and agricultural chemical tanks are other examples of confined spaces.

The Hazardous Occupations Order in Agriculture prohibits hired workers younger than age 16 from working inside confined spaces. See the section, "Hazardous Occupations Order in Agriculture Prohibitions" later in this chapter for more information.

This chapter discusses the hazards of confined-space work areas. **Young workers should not be assigned to work in these confined spaces.**

Confined Space Defined

A confined space is defined by the federal Occupational Safety and Health Administration (OSHA) as:

- a space large enough and so configured a person can enter and perform assigned work
- a space limited in openings for entry and exit purposes
- a space not intended for continuous human occupancy

Although specific standards for agricultural confined-space work areas are not part of the OSHA regulations, the farm work site contains confined space hazards (figure 8.1) and every person associated with the farm should receive training.

Determine if an area meets the definition of a confined space:

- Does the worker enter the area to work by crawling, stooping, crouching, or climbing into it?
- Does the work area have an exit in addition to how it was entered?
- Is there adequate, natural ventilation in the work space?
- Are breathing hazards found in the confined space?
- Can a teen or an adult perform normal body movements for long periods of time within the space?

Youth workers should discuss this type of work assignment with an adult before beginning the job.

Hired youth younger than age 16 are prohibited by regulation from working in confined spaces. No youth younger than 16 should be asked to work in a confined space.

Figure 8.1 A manure pit is a confined space work area. Many lives have been lost in manure pits due to toxic gases and lack of oxygen. Credit: PSU Ag Safety.

Storage Tanks, Milk Tanks, and Oil Tanks

Some confined-space work areas may at first glance appear to be safe for periodic inspection, cleanup, maintenance, or repair tasks. But storage tanks, milk tanks, and oil tanks may present risks to health and safety. Consider these problems:

- an oxygen-deficient atmosphere
- a flammable atmosphere
- a toxic atmosphere

Oxygen-Deficient Atmosphere

The air we breathe contains oxygen. At a minimum, the air should contain 19.5% oxygen. Oxygen levels may be normal when work begins inside a confined space, but the work being done can reduce the oxygen levels as the work proceeds.

Oxygen levels can be decreased by the presence of other gases and vapors. Welding inside a storage tank can deplete oxygen supplies. Chopped hay or corn may ferment during storage, which reduces the available oxygen.

Toxic Atmosphere

Depending upon the storage structure and its use, toxic material may be present when the worker enters the tank. The product stored in the tank may be toxic. Cleaning or scraping the tank can also release toxic chemicals.

The work being performed may cause chemical reactions. Cleaning a milk tank with degreasers and sanitizers must be done according to product directions. Some cleansing materials can harm the eyes and lungs if not handled properly. See the section, “Farmstead Chemicals” in Chapter 5.

Flammable Atmosphere

Flammable materials can be gas, vapor, or dust mixed with oxygen. A source of ignition from welding or an electrical tool can ignite flammable materials. The result could be an explosion inside the confined space.

Petroleum product storage tanks in need of repairs may contain highly flammable materials. These tanks may appear to be empty, but the residual vapors can ignite. Vapors are released when sludge-like materials are scraped from tank walls, which increases the risk of ignition.

Welding on any storage tank should not begin until the welder knows what is inside the tank.

If a worker has to climb into a space to do work, they are confined. Know the risks (figure 8.2).

Figure 8.2 Confined-space entry poses risks to the worker. Credit: J. Mathison.

Working in Trenches

The trench could be a ditch being dug for installation of electric utility or water lines. If assigned to work in a trench, make sure it is a safe place to work.

Trench sidewalls can cave in and trap workers. Death by suffocation is possible. Trench cave-ins have trapped countless people in the past. Follow these safety plans for working in a trench:

- Workers should not enter a ditch with sidewalls higher than their head unless it has steel retainer walls (a trench box) to stabilize it.
- The trench should have "steps" or a sloping ramp cut into the excavation to allow workers to exit easily.
- Workers should use hardhats and lifeline harnesses for protection.
- While working in a trench, workers should be within eyesight of another person who is not in the trench.

Reducing Confined-Space Risks

Confined-space work is usually done on a periodic basis rather than on a regular schedule. Safe work practices may not be remembered and repeated from one work period to another. To reduce the risks associated with working in a confined space, follow these approved practices:

1. **Ventilation**—Ventilate confined-space work areas before entering the area.

2. **Isolate the confined space from entry**—Post signs at the confined-space work area to warn of the hazard. Lockout/Tag out electric circuits to prevent start-up problems.

3. **Test the atmosphere**—If possible, monitor the atmosphere for oxygen deficiency. Most farms will not own the necessary equipment, but fire service companies may have the equipment or the farmer can rent the necessary equipment.

4. **Self-contained breathing apparatus**—Toxic atmosphere confined spaces should not be entered unless the worker is equipped with SCBA and has been trained in its use. Only adults should attempt to work with an SCBA.

5. **Safety equipment**—Safety equipment needs are greater for confined-space work. The appropriate respirator for the specific purpose is required. Hard hats and steel-toed shoes may be required. Communication equipment is needed if direct contact cannot be made with a helper. Spark-proof tools will prevent ignition of flammable gases and dust. In addition, a safety harness and safety lines are advised.

6. **Standby/rescue**—Confined-space work dictates a helper or helpers must be available. Ladders, ropes, harnesses, and lifts make immediate rescue possible. Do not work alone in confined spaces.

Confined-space work requires training and body harness equipment.

Hazardous Occupations Order in Agriculture Prohibitions

Some occupations in agriculture are considered to be particularly hazardous for youth younger than age 16 working as hired help. The Hazardous Occupations Order in Agriculture prohibits youth younger than age 16 from working for hire inside the following areas. They include:

- fruit or grain storage designed to be oxygen-deficient or of a toxic atmosphere
- an upright silo within two weeks after silage has been added or when the unloading device is in operating position
- a manure pit
- a horizontal silo while operating a tractor for packing purposes

Other confined-space work areas may be less well-defined. Many times, a confined space work area does not appear to be hazardous until an injury or fatality provides a reminder of the risks.

Upright Silos

Silos serve the purpose of providing a storage space for finely chopped forages. These feeds ferment and become acidic. The low pH prevents bacteria from spoiling the silage.

Silos can be an upright tower or a trench, bunker, or stack or bag on the ground. Each has its own set of safety hazards. This section discusses the safety considerations a worker must understand when working with upright silos. Upright silos are a confined space.

There are two types of upright silos, conventional and oxygen-limiting (figure 8.3).

Conventional silos are normally made of brick staves, hatch doors, and a metal roof that is not airtight. Oxygen-limiting silos are most often glass-lined, do not have hatch doors, and have an airtight roof.

Both types of silos are loaded by blowing the silage to the top of the silo, but unloading each type is different. Conventional silos have hatch doors at the top of the silo, which are opened to allow the silage to be unloaded. The unloader inside the silo sits on top of the silage and is lowered by the farmer as the silage is removed. Oxygen-limiting silos are unloaded at the bottom of the silo, where the unloader is located. Silage is knocked loose and transferred out of the bottom door by a conveyor.

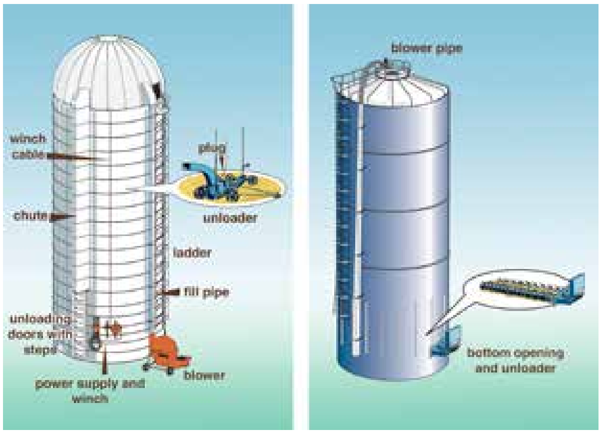

Figure 8.3 A conventional silo with loading and unloading equipment is shown on the left while the right side shows an oxygen-limiting silo with its loading and unloading equipment. Credit: Penn State Ag Safety.

Silage Chemistry

Silage fermentation is the process of controlling bacterial actions that naturally break down the plant fibers of corn, hay, and other crops. Ideal silage is produced when silo oxygen is used up. The silage becomes more acidic, which prevents further spoilage until oxygen enters the silo as the silage is fed.

Silo Gas

Silo gas is formed as the stored crop begins to ferment. Nitrogen dioxide and carbon dioxide are produced as the oxygen in the crop is depleted. During the first few days after filling the silo, these gases increase.

The type of silo determines which silo gas will predominate. In an oxygen-limited silo, carbon dioxide, an odorless, colorless, heavier-than-air gas is produced in large quantities. In a conventional silo, nitrogen dioxide, a heavy, yellowish-brown gas with a bleach-like odor is released. This heavier-than-air gas settles to low spots, including feed rooms. Both of these gases cause death through lack of oxygen.

Working Safely with the Chemistry of Silage

Understanding how silage is produced helps to prevent exposure to deadly silo gases. To prevent silage gas health problems, observe these precautions:

- Stay out of newly filled silos for at least two weeks. A trained adult should use self-contained breathing apparatus if the silo must be entered.
- Close the feed room door to the barn.
- If the silo must be entered by an adult:
    - Run the ventilation fan.
    - A second adult should stand by in case of emergency.
    - If testing shows silo gas is not an issue, wear a dust mask to protect against silage dust.

Silage gas can kill!

Grain Bins

Unloading grain from storage bins and wagons exposes workers to the risk of being pulled into the flow of the grain and becoming trapped. Moldy, damp grain creates a flow problem, often leading workers toward unseen hazards. Children playing in and around grain storage areas are often victims. Flowing grain entrapments cause an average of 12 deaths each year in the United States. This section discusses the hazards of flowing grain in storage bins, wagons, and trucks.

Flowing Grain

Grain harvest produces huge amounts of material to transport and store. Fortunately, many labor-saving devices have been developed to make grain handling fast and efficient. Augers move grain rapidly. Gravity-flow wagons and trucks make grain movement efficient. But flowing grain creates many hazards.

Augers move grain from the bottom center of storage bins to the outer edge of the bin and into grain-hauling vehicles or other storage bins. When the auger is running, grain flows out of the bin from directly above the outlet of the unloading auger in the center of the bin floor. A funnel-shaped flow on the top of the grain occurs with the grain flowing in a column below the surface toward the outlet (figure 8.4). This flow is like a moving conveyor belt or escalator.

With a large auger, a worker inside the bin can be pulled knee deep into the column of grain within a few seconds. Once the knees are covered by grain, getting free without the assistance of others is almost impossible. If the knees are covered and the grain is still flowing, the flowing grain is similar to quicksand. It can completely engulf a person very quickly. Figures 8.5 and 8.6 illustrate how quickly a person will sink into flowing grain.

Note: Gravity unloading wagons have similar grain-flow patterns as grain bins. The grain flows in a funnel-shaped form with a column of grain moving toward the unloading door of the wagon or truck.

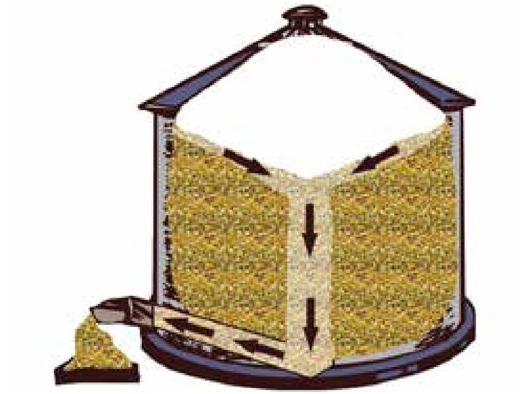

Figure 8.4 The normal flow of grain from a bin is off the top and down a center column of grain flowing toward the unloading auger. The unloading auger is found at the bottom center of the grain bin. Credit: PSU Ag Safety.

Figure 8.5 If a person stands on top of the grain while the unloading auger is running, grain flowing out of storage causes a downward-moving floor to move away from the person's feet. The victim is pulled waist deep in about 10 seconds. Credit: PSU Ag Safety.

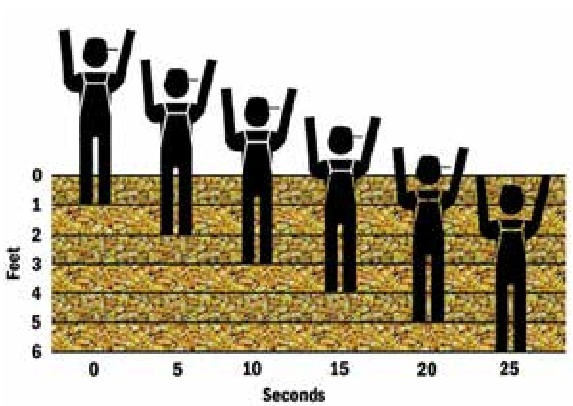

Figure 8.6 In a few seconds, a person standing in the grain bin can be helplessly trapped as the grain begins to flow. A person can be completely engulfed in the grain in about 25 seconds. Death from suffocation most often results. Credit: PSU Ag Safety.

A 10-inch auger can move 85 cubic feet or 65 bushels of grain per minute. Within seconds, a person can be helplessly trapped in flowing grain.

Grain Bridging

Grain harvested before it has dried adequately is damp and can mold quickly. This damp, moldy grain clumps together and hardens into a crusty mass. It gives the appearance of being a solid walking surface. This is often not recognized as a hazard.

As poorly conditioned grain is unloaded from the bin, a cavity may develop unseen, below the crusty mass of moldy grain at the top (figure 8.7). The worker sees the grain has stopped flowing, but the bin appears full. The temptation is to enter the bin to break up the "grain bridge." The grain bridge gives way as the worker walks over it (figure 8.8), and they are pulled into the flowing grain.

Figure 8.7 A "grain bridge" cannot support the weight of the worker. Credit: PSU Ag Safety.

Figure 8.8 As the grain bridge gives way, the worker is pulled into the pocket and is engulfed. The grain auger may have been left running and the flowing grain pulls the victim under the grain. Credit: PSU Ag Safety.

Wall of Grain Avalanches

In some cases, moldy grain will be found sticking to the walls of the bin. After removing the loose grain, the worker may encounter a wall of crusted grain that must be loosened before unloading. An avalanche may occur as the worker tries to break up the crusted wall of grain. If the wall of grain is higher than the height of the worker when the worker stands on the grain bin floor, this avalanche could completely engulf the worker, leading to injury and possible death (figure 8.9). One foot of grain covering the engulfed worker would weigh approximately 300 pounds. This is normally too much weight for individuals to move to free themselves.

Figure 8.9 Damp, moldy grain can stick to the side of the grain bin. It can collapse on the worker who tries to dislodge it. Credit: PSU Ag Safety.

Preventing Flowing Grain Entrapment

The following steps can reduce the risk of flowing grain entrapment in storage bins, wagons, and trucks. These practices can save lives.

- Place entrapment warning decals on grain bins and grain transport vehicles.
- Prevent unauthorized entry to grain bins and grain transport vehicles, especially by children.
- Make sure all workers and children are aware of entrapment hazards.
- Keep grain in proper condition. This may include the use of mechanical stirrers to prevent the grain from molding. Out-of-condition grain is considered the leading cause of adult entrapments.
- Use inspection holes or grain bin level markers instead of entering a grain bin.
- Enter a grain bin or grain transport vehicle only if it is absolutely necessary. Use a body harness secured to the outside of the bin or vehicle.
- Use a pole from outside the bin to break up possible grain bridges.
- Lockout/tagout all power controls before entering a bin. A lockout device prevents the unexpected start-up of a machine and potential injury. A tagout sign provides a prominent warning: equipment cannot be operated until the sign is removed.
- Have at least two observers present during grain bin entry.
- Establish a form of nonverbal communication with observers (hand signals).
- Work from top to bottom when cleaning grain bin walls.

Special Notes:

Small children do not understand the hazards of agricultural work. Grain brought from the field to the farmstead has play appeal. Machinery moving grain draws their attention. The risks of a child being entrapped in flowing grain are very high. Most children do not survive grain storage entrapments.

Rescuing victims of grain bin entrapments calls for special tools and expertise from local EMS groups (figure 8.10).

A 12-inch layer of corn covering a victim can weigh as much as 300 pounds.

Figure 8.10 It takes much force to remove a grain bin entrapment victim. Rather than removing the victim, it is easier to remove the grain. Special tools and skills are needed to cut through grain bins and remove the grain. Credit: PSU Ag Safety.

Special Note

Grain vacuum equipment (figure 8.11) is becoming popular. The vacuum can quickly move grain from trucks to bins or can be used in more remote locations to empty wagons onto trucks. These vacuums can be moved over the top of the grain in a side-to-side sweeping motion, and can remove thousands of bushels per hour. The vacuum should be held at an angle away from the body. If held close to the body, grain can rapidly be removed from underfoot, quickly pulling the worker down into the grain, possibly entrapping them in the grain.

Figure 8.11 A grain vacuum moves large quantities of grain from storage to truck, or from truck to grain bin. Credit: J. Mathison.

Manure Storage

The manure pit is full. It must be agitated and spread on the field. This is a repeated routine in animal agriculture. The daily caution with machine hazards is combined with exposure to manure gases.

Farm work exposes the worker to a variety of sights, sounds, and odors. Some of the odors, such as manure, are more than the strong smell. Some odors come from hazardous gases, which can also be harmful.

This section discusses manure storage and the production of hazardous gases from storing manure. Understanding manure gases is important for people working in animal agriculture.

Manure Storage Structures

Manure storage structures vary in size and type. The farm's animal numbers, the length of storage time needed, and the soil structure where the storage unit is built will influence what type of manure storage is used. Modern animal agricultural practices and environmental laws make storage and management of manure a normal farming routine.

Manure storage is considered a confined space work area (see above).

Aboveground Storage

Manure sheds and aboveground storage tanks are used to store manure in many areas. The shed may have a roof covering and open sides. Manure tanks are often open-top, silo-type structures. Semisolid manure may be removed from sheds by tractor high-lifts. Liquid manure in tanks must be agitated and pumped to manure spreaders. In some cases, liquid manure is removed from storage by way of irrigation systems.

Belowground Storage

Manure storage pits may be separate structures from the barn or below the barn itself. Some manure pits are open. Manure is scraped into the pit. Other manure pits have slotted floors and storage lids or caps for covers. Animal foot traffic and gravity fill the pit. Pump-out pits are usually of smaller capacity, serve as temporary storage structures, and are pumped to larger storage structures.

Manure storage pits directly beneath animals (figure 8.12), pits under the farm building, and closed or covered pump-out pits pose the most risk of producing manure storage gas hazards. Fatalities to humans and to livestock have been documented.

Although odor may be a tell-tale sign indicating the presence of manure gas, several toxic gases are odorless and colorless when present.

A manure pit often lacks the oxygen needed to keep people alive.

Figure 8.12 Slotted floors, like this example in a dairy barn, cover a manure storage that may be up to 10 feet deep, usually referred to as a deep-pit storage. Slotted floors are also used extensively in swine facilities. Credit: PSU Ag Safety.

Manure Gases

Manure is the product of digestion. Undigested feed materials, body cells and tissues, and minerals pass through the animal and are excreted. This material is in the beginning stages of decomposition or fermentation. Decomposition and fermentation produce gases.

Manure gases are toxic (figure 8.13). Low-level exposure produces lung and eye irritations, dizziness, drowsiness, and headaches. Additionally, some manure gases are heavier than air and deplete or displace the oxygen in the storage area. High levels of manure gases can quickly render a person unconscious. Death from suffocation can occur.

Figure 8.13 Open manure storage areas pose a less deadly gas hazard than belowground pits. The major hazard of the open manure storage is drowning. Fencing and warning signs alert people to the liquid manure hazard. Credit: J. Mathison.

Four hazardous gases can be found in stored manure:

- hydrogen sulfide
- ammonia
- carbon dioxide
- methane

Hydrogen sulfide—Hydrogen sulfide has a foul odor similar to rotten eggs. It is rapidly released from agitated manure. It can cause headache, dizziness, and nausea in as low a concentration as 0.5%. At a concentration of 1% in the atmosphere, hydrogen sulfide can cause death. It is heavier than air and settles to the lower level of the manure storage or on top of the manure level.

Ammonia—Ammonia is a colorless pungent gas with a bleach-like odor. It is soluble in water and irritates the eyes, nostrils, lungs, and throat. The burning effect on the eyes and nose is reduced with breathing fresh air. It is lighter than air and rises out of the storage area rapidly.

Carbon dioxide—Carbon dioxide is an odorless and colorless gas. It exists in low levels in the air we breathe, but high concentration causes difficult breathing, headaches, and even death. It is heavier than air and concentrates in low areas of the storage structure.

Methane—Methane is a nontoxic, colorless, odorless but explosive gas. This gas is lighter than air and rises from storage areas. Headaches may be experienced in methane concentrations of 50% of the atmosphere. Methane in manure gas is just as explosive as the methane gas found in a coal mine.

All of these gases are released into the atmosphere when manure is agitated and pumped prior to spreading. The gases can also remain in the manure pit or tank even after the manure is removed.

Concentrated manure gases can suffocate someone instantly!

Manure Gases Can Kill

A 31-year-old male dairy farmer and his 33-year-old brother died after entering a 25-square-foot, 4.5-foot-deep manure pit inside a building on their farm. A pump intake pipe in the pit had clogged, and the farmer descended into the pit to clear the obstruction. While in the pit, he was overcome and collapsed. The victim's brother was standing at the entrance of the pit and apparently saw the victim collapse. He entered the pit in an attempt to rescue him. The brother was overcome and collapsed inside the pit. Four hours later, another family member discovered the two victims inside the pit and called the local fire department to rescue them. The victims were pronounced dead at the scene by the coroner. The coroner's report attributed the cause of death in both cases to methane asphyxiation.

Even people in the vicinity of a manure pit or an open-air storage being agitated or emptied can be overcome by the fumes. Especially when there is high humidity and no wind, the gas does not easily dissipate. This has happened in Pennsylvania. Children who were riding their bikes near an open-air storage (figure 8.13) being emptied got sick and passed out. In another case, someone who was working in a garden near a pit was overcome. Everyone should stay well away from the area.

Figure 8.13 Open manure storage areas pose a less deadly gas hazard than belowground pits. The major hazard of the open manure storage is drowning. Fencing and warning signs alert people to the liquid manure hazard. Credit: J. Mathison.

Manure Storage Precautions

Safe work practices can be applied to manure storage areas. The following approved practices will reduce the risk of exposure to deadly manure gases and drowning hazards:

- Keep people and animals out of confinement buildings during manure storage agitation and pumping.
- Ventilate the area for several hours following pumping activities. A back-up ventilation system and emergency power source should be considered in the event the power fails.
- Allow 1 to 2 feet of air space above the manure surface for gases.
- Eliminate or prohibit smoking or any source of ignition near manure storage facilities.

- Keep manure agitators below the liquid manure's surface to reduce the volume of gas released.
- Remove temporary access ladders leaning against aboveground manure tanks.
- Lock access to permanent ladders on aboveground manure tanks.
- Do not drive on crusted manure surfaces of aboveground, open-air manure storage tanks, because the crust is not uniformly solid and can break.
- Warn visitors and guests of the hazards of manure storage areas (figure 8.14).
- Provide signs at the manure storage area, and give verbal instruction to all visitors and guests.

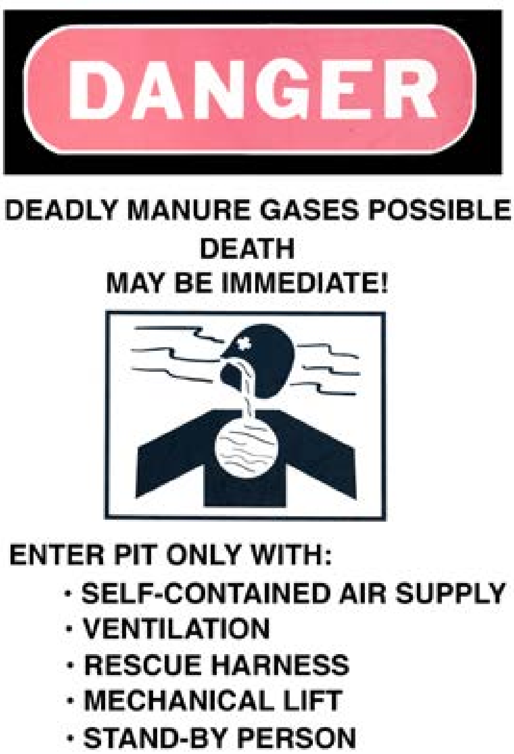

Figure 8.14 A danger sign posted near a manure storage structure provides a clear warning that immediate death is possible from manure gases. Credit: J. Mathison.

Do not enter a manure pit for any reason.

Manure Storage Emergencies: Best Safety Practices for Prevention

1. Post signs that warn people of a potentially hazardous atmosphere. Barricade the entry when it is open.
2. Write an entry plan for each space on the farm known to be hazardous. The plan should include the potential hazards, why entry might be needed, and what specific procedures must be followed to allow entry.
3. Do not enter the space without at least two adults present. The person entering the space must be knowledgeable about potential hazards and what to do if something goes wrong inside. The second person must always remain outside the space and be in clear view or voice contact with the person inside. The second person's job is to get help and operate a retrieval system if needed. They should never enter the space to help with the job or to aid a person who has collapsed.
4. Before entering, test the space for toxic or explosive gases and oxygen deficiency (figure 8.15). A gas detection device (figure 8.16) can test for oxygen, explosive gases, and hydrogen sulfide and can be purchased, leased, or borrowed. A recent internet search found meters available for rent for about $25/day or $88/week. Proper use and interpretation of these instruments is important. Renting from a reputable source helps to ensure that the meter is calibrated and operating when it is shipped. Selecting and using gas detection equipment is discussed in Penn State Extension Fact Sheet E 51, Confined Space Manure Storage Hazards. This fact sheet is available at **extension.psu.edu/confined-space-manure-storage-hazards**.

5. Before entering a potentially hazardous space, ventilate the space to dilute toxic and flammable gases and to provide fresh air. Ventilation should continue while work is being performed in the pit. Properly ventilating manure storages is discussed in Fact Sheet E 53, Confined Space Manure Storage Ventilation Systems, available online at **extension.psu.edu/confined-space-manure-storage-ventilation-systems**.
6. Anyone who enters a hazardous area should wear a body harness (figure 8.17) attached to a fall arrest and retrieval system, which can be used to remove them if they become incapacitated. The system allows a single person to retrieve the victim from the confined space. Commercial tripod and winch units designed for confined space entry work can be rented for around $100 per day, or purchased for $1,500–$2,500. More information about retrieval systems for confined spaces can be found at extension.psu.edu/confined-space-manure-storage-emergencies.
7. Lockout all power sources before entering a manure storage. This is typically done by disconnecting the agitator PTO from the tractor, or removing the tractor or agitator from the manure pit. Other hidden dangers of manure storages are (a) stray electricity caused by a shorting motor on a sump pump or agitator, or (b) motors inadvertently starting while someone is in the space, causing an entrapment. Ensuring that the electrical circuit is off and locked out will guarantee that there will be no electrocutions or unwanted start-ups of pumps or agitators.

Figure 8.15 Always remain outside the manure storage facility when taking initial gas measurements. Credit: PSU Ag Safety.

Figure 8.16 Hand-held, portable multi-gas monitors measure most of the manure gases and oxygen levels. Credit: PSU Ag Safety.

Figure 8.17 An appropriate body harness loops around both legs and the person's shoulders, and has a lifting point centered between the shoulders on the back so the person can be safely lifted by a winch. Credit: PSU Ag Safety.

ACTIVITY 8.1

Silo and Silage Hazards

LEADER NOTES

Skill Level: Beginner to Advanced

Ages: 8–18

Learner Outcomes: Learn how to work safely in and around the confined space of various types of silos. Learn how silos and related equipment present hazards and how to avoid those hazards.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

FPP.01. Develop and implement procedures to ensure safety, sanitation, and quality in food product and processing facilities.

PST.02. Operate and maintain AFNR mechanical equipment and power systems.

Success Indicators: Youth completes parts 1–5 below and knows the potential hazards of working in and around silos and related equipment. Youth understands how to avoid these hazards.

Life Skills: Personal safety, hazard prevention

Tags: Personal safety, confined space, silo, silage, suffocation hazard, silo gas, fall hazard, personal protective equipment

Time Needed: 1–3 hours, not including travel time to farms

Materials List:

- computer(s) with internet connectivity
- copies of Let's Do It!
- pens/pencils

Space: Farm; classroom or other indoor space

Suggested Group Size: One to 10 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: If possible, arrange a trip to watch silo filling. If it's not possible to go during filling time, try to arrange a visit to two or three farms with different kinds of silos. Do not let any youth enter a confined space as part of the activity.

Introduction: Review Chapter 8, Confined Spaces (through Trenches, Bunkers, and Silos)

Opening Questions: If you know someone who has had an incident with a silo, silage, or silage filling equipment, share the story with the group. What could the person have done differently to avoid the hazard?

LET'S DO IT!

ACTIVITY 8.1

Silo and Silage Hazards

1. What do oxygen-limiting silos and conventional upright silos have in common?

2. Summarize the potential hazards of oxygen-limiting silos and conventional upright silos.

3. Visit a local farm with an upright silo to learn more about how the silo is loaded, unloaded, ventilated, and kept safe from youngsters or visitors. Develop warning signs that could advise operators or visitors about the dangers of upright silos.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More: To see another set of suggested silo safety activities, visit **progressiveag.org**.

ACTIVITY 8.2

Grain Bin Safety

LEADER NOTES

Skill Level: Beginner to Advanced

Ages: 8–18

Learner Outcomes: Learn how flowing grains can be hazardous and how to avoid those hazards with bins, wagons, and trucks.

Education Standards: **CRP.01.** Act as a responsible and contributing citizen and employee.

CS.03. Examine and summarize the importance of health, safety, and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

FPP.01. Develop and implement procedures to ensure safety, sanitation, and quality in food product and processing facilities.

Success Indicators: Youth completes parts 1–2 below and can explain how flowing grain can be a deadly hazard and understands how to work safely around flowing grain bins, wagons, and trucks.

Life Skills: Personal safety, hazard prevention, research

Tags: Personal safety, confined space, grain bin, flowing grain, entrapment, suffocation hazard, fall hazard, personal protective equipment

Time Needed: 1 hour, not including travel time to farm

Materials List:

- copies of Let's Do It!
- pens/pencils
- paper
- clipboards
- computer(s) with internet connectivity

Space: Farm; classroom or other indoor space

Suggested Group Size: One to 10 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Arrange to visit a farm, grain elevator, or feed mill to observe grain being unloaded.

Introduction: Review Chapter 8, Confined Spaces, Grain Bins section.

Opening Questions: If you know someone who has had an incident with flowing grains or related equipment, share the story with the group. What could the person have done differently to avoid the hazard?

LET'S DO IT!

ACTIVITY 8.2

Grain Bin Safety

1. Visit a farm, grain elevator, or feed mill to observe grain being unloaded. Make a list of the hazards that can be found in this job. List the ways that the workers stay safe while doing this job.

2. Search the internet of the land grant university college of agriculture in your state to find information about grain moisture levels considered safe for preventing moldy grain. Fill in the blanks in the following chart.

Grain	% Moisture Level Recommended for Safe Storage
Soybean	
Shelled corn	
Wheat	
Barley	
Oats	
Sorghum	

Why is it important to know and use these moisture levels?

____

____

____

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More: To see another set of suggested grain safety activities, visit **progressiveag.org**.

ACTIVITY 8.3

Manure Storage Safety

LEADER NOTES

Skill Level: Beginner to Advanced

Ages: 8–18

Learner Outcomes: Learn about the hazards surrounding various types of manure storages and safety measures to take around these hazards.

Education Standards: **CRP.02.** Apply appropriate academic and technical skills.

CS.03. Examine and summarize the importance of health, safety and environmental management systems in agriculture, food, and natural resources (AFNR) workplaces.

Success Indicators: Youth completes parts 1–3 below, understands the hazards of various kinds of liquid and semisolid manure storages, and the basics of how to work safely around manure storages.

Life Skills: Personal safety, hazard prevention, research, writing

Tags: Personal safety, confined space, manure storage, manure gas, personal protective equipment

Time Needed: 1–2 hours

Materials List:

- copies of Let's Do It!
- pens/pencils
- computer(s) with internet connectivity

Space: Classroom or other indoor space

Suggested Group Size: One to 10 people

Acknowledgment: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Experience:

Before the Activity: Invite your local volunteer rescue service to demonstrate the equipment and techniques they need to effectively respond to a confined space entrapment. This can be done aboveground in the open. **Don't let any youth enter a confined space as part of the activity**.

Introduction: Review Chapter 8, Confined Spaces.

Opening Questions: Do you know of farms in your area that store manure for at least 30 days? What types of storages do they have? For example, are they belowground pits, above ground tanks, or ground-level ponds? What are the hazards of each type of manure storage?

LET'S DO IT!

ACTIVITY 8.3

Manure Storage Safety

1. Using farm magazines, newspapers, the internet, or another source, make a collection of news articles about manure storage injuries or fatalities. Identify the mistake(s) made that led to the incidents.

2. Research the topic "positive ventilation systems." Determine which is better at ventilating a manure pit: a positive ventilation system or a negative ventilation system. Write out your answer or explain your answer to your instructor or leader.

3. Watch your local volunteer rescue service demonstrate the equipment and techniques they need to effectively respond to a confined space entrapment.

Reference: Penn State Extension, Ohio State University Extension, and the National Safety Council. 2020. *National Safe Tractor and Machinery Operation Program, Student Manual,* 3rd ed. AGRS-153. Ag Communications and Marketing, The Pennsylvania State University.

Learn More: To see another set of suggested manure storage safety activities, visit **progressiveag.org**.

Glossary

articulated tractor. An articulated tractor with an oscillating frame keeps all four drive tires on the ground even on the roughest terrain. The tractor frame pivots in the center, allowing the rear tires to follow the same path as the front tires.

auto-ignition. Occurs when flammable materials stored near an open flame or where heat can build up spontaneously ignites.

burn point. A place on machinery that is hot. Examples include mufflers, engine blocks, pipes, and fluids.

caustic. Capable of burning skin or eating away at other materials; corrosive.

combustible. The capacity to be burned makes a material combustible.

crush point. Formed when two objects are moving toward each other, or when one object is moving toward a stationary object, and the gap between the two is decreasing. A common example of a crush point occurs when an implement is attached to a tractor's drawbar.

differential lock. Overrides the differential axle drive, creating a fixed axel and forcing the wheels to rotate at the same speed. The differential is necessary when, for example, a tractor is making a tight turn; a differential lock is necessary when, for example, one tractor tire is spinning in mud and more traction is needed.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The federal law pertaining to pesticides and administered by the U.S. Environmental Protection Agency.

flammable. Materials that can explode or ignite and burn violently. Used interchangeably with the term "combustible."

flash point. A point at room temperature where a solvent will produce vapors in enough concentration to ignite when brought near a source of heat.

freewheeling parts. Parts of a machine that continue to move after the power to the machine has been turned off.

Hazardous Occupations Orders for Agriculture (AgHOs). Part of the U.S. Department of Labor's Fair Labor Standards Act (1938) as amended in 1968. The AgHOs prohibit children under the age of 16 from being hired to perform specified hazardous jobs on the farm. An exemption is provided that allows 14- and 15-year-olds to perform specified hazardous acts if they have successfully passed training in tractor safety and/or safe tractor and machinery operation. See dol.gov/whd/state/agriemp2.htm for information about your state's rules.

kindling point/ignition point. The lowest temperature at which a solid material will ignite and begin to burn when brought near a source of heat.

personal protective equipment (PPE). Safety equipment designed to protect a person from injury and illness. Examples include goggles, aprons, boots, hard hats, and gloves.

pinch point. Formed when two machine parts move together and at least one of the parts moves in a circle. Body parts or clothing or other materials can be pinched. This type of hazard is often found in power transmission systems such as belt drives, chain drives, and gear drives.

power takeoff (PTO). A rotating part at the rear of the tractor that transfers power from the tractor to PTO-powered machinery.

pull-in point. A place on machinery where rotating parts come in close contact with each other and the danger exists of a person or clothing being pulled into the machinery. Pull-in points occur frequently on harvesting machinery.

restricted use pesticide (RUP). These pesticides demand special attention due to their ability to harm humans, livestock, wildlife, or the environment even when used according to label directions.

shear point. Place on a machine where the edges of two parts move across or close enough to each other to cut a relatively soft material. At least one of the two objects must be moving. Hedge trimmers are a good example of a machine with a shear point.

solvent. Substance that dissolves other substances.

spontaneous combustion. The phenomenon in which a material unexpectedly bursts into flames without apparent cause.

stored energy hazard. Occurs when energy that is confined is released unexpectedly. This hazard is present in pressurized systems and their components. Examples include springs, and hydraulic, pneumatic, and electrical systems.

toxic. Poisonous.

thrown object hazard. Occurs as normal machine operations discharge materials into the surrounding environment. A common example is rocks thrown by a mower.

vapors. The gas form of substances that are normally in the solid or liquid form.

volatility. The tendency of a liquid to vaporize or evaporate into the air. Gasoline is volatile.

Worker Protection Standard. Part of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Pertains to the protection of agricultural workers and handlers from occupational exposure to pesticides in agricultural operations.

wrap point. Rotating part of a machine where a person's clothing, body, or other materials can become entangled. An unguarded PTO is a wrap point.

Answer Key

Most of the activities in this book ask students to think about examples from their personal experience. For this reason, the activities often have no definite answers. The activities with definite, correct answers are included here.

Activity 1.3. Mechanical Hazards, Question 1 (page 46)

1. burn point
2. pinch point
3. freewheeling part
4. wrap point
5. thrown objects
6. shear point
7. stored energy
8. crush point
9. pull-in point

Activity 1.4. Reaction Time, Questions 3, 4, and 5 (page 50)

3. 15 revolutions ((1,800 / 60) x 0.5)
4. 4.5 turns ((540 / 60) x 0.5)
5. 8.33 turns ((1,000 / 60) x 0.5)

Activity 1.5. Personal Protective Equipment, Question 1 (page 54)

tasks or chores	
A. Mowing grass	**3 or 8**
B. Pouring detergent to clean milking equipment	**2, 10**
C. Grinding a broken bolt	**2, 10**
D. Sweeping driveway	**1**
E. Working in part of an old barn with a low ceiling	**6**
F. Applying lime	**4**
G. Helping to trim branches	**2, 6, 10**
H. Using a grain elevator	**3 or 8, 10**
I. Weeding	**9**
J. Spray-painting	**5**
K. Sweeping up moldy grain in grain bin	**7**

Activity 1.5. Personal Protective Equipment, Question 3 (page 55)

Four safety issues with clothing: loose, long hair; dangling necklace; baggy shorts; frayed cuffs; and untied laces.

Activity 1.6. Safety Signs and Signals, Questions 1 and 2 (Page 61)

Question 1 answers:

1. Safety alert symbol
2. Danger—entanglement hazard (auger)
3. Warning—crushing hazard
4. Danger—PTO entanglement hazard
5. Danger—potential crushing hazard to hands
6. Live electrical wire hazard
7. No riders on tractors
8. Caution—hot surface
9. ATV rollover hazard
10. Caution—Hot fluid under pressure
11. Wear a seat belt
12. Thrown objects hazard

Question 2 answers:

meaning	signal
A. this far to go	1
B. start the engine	8
C. increase speed	6
D. lower the equipment	10
E. decrease speed	7
F. move out—take off	4
G. raise the equipment	11
H. come to me	2
I. move toward me—follow me	3
J. stop	5
K. stop the engine	9

Activity 2.2. Introduction to the Tractor Instrument Panel and Controls, Part 1 Quiz (Page 111)

1. C
2. D
3. C
4. B
5. C, D, B, A

Activity 2.5. Tractor Operation Symbols and Preventive Maintenance, Part 1 Quiz (Page 123)

2. C
3. C

Activity 2.8. Safely Starting and Stopping Tractor Engines, Part 1 Quiz (Page 134)

1. False
2. B
3. Compressing the air in the cylinder makes it hot enough to burn fuel
4. Allows lubricants to warm up, which protects engine from wear.
5. You can damage the starter or run down the battery.
6. False
7. False
8. C. Carbon monoxide
9. In diesel engines, they preheat the air in the combustion chamber.

Activity 2.9. Tractor Stability, Question 1 (Page 134)

1) A tractor overturns when it A) is operated on a steep slope; B) has its center of gravity raised above its natural location several inches above the rear axle, such as with a front load; C) is traveling too fast for the sharpness of the turn; D) has power applied to its rear wheels too quickly; E) is used to pull a load that is not hitched to the drawbar.

Activity 3.2. Making PTO Connections, Questions 1 and 2 (Page 169)

1. A. 540
   B. 1,000
   C. 1,000
   D. 10%–15%
2. A. 9.42 inches
   B. 9 rev/sec
   C. 27 rev/3 sec
   D. 254 inches (>21 feet)

Activity 3.3. Implements With Hydraulic and/or Electrical Components, Question 1 (Page 173)

A. Dirt
B. Fluid under pressure
C. 2,000 psi
D. 3

Activity 4.2. Driving and Operating a Skid Steer, Question 1 (Page 210)

A. 5
B. 2
C. 3
D. 4
E. 1
F. 7
G. 6

Activity 4.6. Tractor Front-End Loaders, Question 1 (Page 224)

A. It raises the center of gravity
B. You could unintentionally bump a control while getting off, or the tractor could roll, potentially leading to an injury.
C. If the load is larger than the size of the bucket, load rollback can occur.

Activity 4.7. Augers and Elevators Loaders, Question 2 (Page 227)

48.75 bushels (7.5:10 inches = X:65 bushels)

Activity 4.8. Silage Defacers, Silage-Bagging, and Bale-Wrapping Equipment, Question 4 (Page 230)

Formula for initial tube volume: 3.14 x 42 x 200 = 10,048 cubic feet. If a cubic foot of corn silage weighs 35 lbs., how many tons of silage are being stored?

10,048 cf x 35 pounds = 351,680 pounds >> 351,680 / 2,000 = 175.84 tons

175.84 tons

Activity 5.1 Weather Hazards, Question 1 (Page 272)

1. b
2. c
3. d
4. a

Activity 5.4: Electrical and Fire Safety, Questions 6 and 7 (Page 284)

6. Class C. Class C fires involve electricity.
7. Yes, the soil would smother the fire, eliminating its oxygen.

Activity 8.1 Silo and Silage Hazards, Questions 1 and 2 (Page 330)

1. Both types of silos provide storage space for finely chopped forages, and both are loaded by blowing the silage to the top of the silo
2. In an oxygen-limited silo, carbon dioxide, an odorless, colorless, heavier-than-air gas, is produced in large quantities and can cause death through lack of oxygen.

Activity 8.2: Grain Bin Safety, Question 2 (Page 333)

Grain	**% Moisture Level Recommended for Safe Storage**
Soybean	11–14
Shelled corn	13–15
Wheat	13–14
Barley	13–14
Oats	13–14
Sorghum	13–15

Source: extension.purdue.edu/extmedia/AED/AED-20.html

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Ohio State University Extension, 4-H Youth Development publications are available through local OSU Extension offices and online at **extensionpubs.osu.edu**. Ohio residents get the price when they order and pick up their purchases through local Extension offices.

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