STUDENT MANUAL

National Safe Tractor and Machinery Operation Program

Revised Third Edition
Developed by Penn State Extension, Ohio State Extension, and the National Safety Council

PennState Extension

National Safe Tractor and Machinery Operation Program

Student Manual

Revised Third Edition

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Introduction

The United States Department of Labor (U.S. DOL) Fair Labor Standards Act of 1938 identified several hazardous occupations for which individuals employed had to be 18 years of age or older. The identified occupations included manufacturing and mining. In 1968, the Fair Labor Standards Act was amended to include the Hazardous Occupations Order in Agriculture. This order established the minimum age for employment in agriculture as 16 years of age or 14 years of age with special training. The order also identified hazardous operations and farm tasks, such as operating a tractor over 20 horsepower and other farm machinery, including but not limited to a corn picker, combine, hay baler, feed grinder, forklift or power post driver. Several exemptions are provided under the law, such as (1) minors who are employed on a farm owned and operated by their parents or guardians or (2) minors ages 14 and 15 who have received training and certification from an approved tractor and farm machinery safety certification program.

Each state is responsible for providing the approved safety training that allows minors ages 14 or 15 to legally be employed to operate a tractor or other specific machinery. Youth can receive a U.S. DOL certificate of training for tractor driving by completing four hours of orientation to on-farm hazards and general safety and participating in a 10-hour tractor safety course. With an additional 10-hour machinery safety course, youth receive a certificate of training for machinery operation. Individuals 16 years of age and older can be employed in agriculture without this certification.

If you would like to become a student or instructor in the National Safe Tractor and Machinery Operation Program, go to **nstmop.psu.edu** or call 814-865-7685.

Regulations

The U.S. DOL regulations that relate to occupations in agriculture that are particularly hazardous for the employment of children younger than age 16 are found in the Code of Federal Regulations, Title 29, Part 570, Subpart E-1 (29 CFR 570 Subpart E-1). Task Sheet 1.2.1: Hazardous Occupations Order in Agriculture summarizes what youth younger than age 16 and their parents and employers need to know about the regulations. The official regulations can be found on at the U.S. DOL website (**www.dol.gov**).

Training Programs

In order to operate tractors and machinery, you must receive a minimum of 24 hours of instruction focused on Minimum Core Content Areas (MCCA). This requires significant meeting time. This instruction may take place over several weeks and can include group discussions, demonstrations, field trips to farms or equipment dealers, and hands-on activities. In addition to classroom instruction, you should be expected to complete study or field assignments, which may be used to meet the 24-hour requirement.

Curriculum Materials

The task sheets are the primary curriculum resource for the program and may be used alone or supplemented with additional information and instructor knowledge. Some examples are other written texts, other instructional task sheets, student worksheets, tractor and machine operator and service manuals, demonstrations, vendor tractor and equipment safety videos, and guest speakers.

Instructional Methods

The materials are designed to be used in a variety of instructional settings. They can be used in a traditional classroom setting (e.g., a formal high school agricultural classroom), an extension/4-H evening or Saturday meeting format, an independent study format, or some combination.

Testing Procedures

1. You must be at least 14 years of age on the test date to be allowed to take the operating skills and pre-op/driving tests. If you are under the age of 14, you are permitted to attend educational classes only and take the written test, but you may not operate tractors or other equipment if practice sessions are held.
2. The written, operating skills, and pre-op/driving tests must be passed with a minimum score of 70 percent before you can be awarded a U.S. DOL certificate of training. The locations where these tests are given hereafter are referenced as test stations.
3. The written test will consist of 50 questions generated from a question bank based on task sheets that cover the MCCA. The written test consists of both multiple-choice and true/false questions. You must pass the written test with a 70 percent or better before you can move on to the skills test.
4. You must pass first the written test and then the operating skills test before you can take the pre-op/driving test.

Written Test

The goal of the written test is to evaluate your knowledge of the agricultural safety and health topics that are listed in the MCCA for the National Safe Tractor and Machinery Operation Program.

Operating Skills and Pre-Op/Driving Test

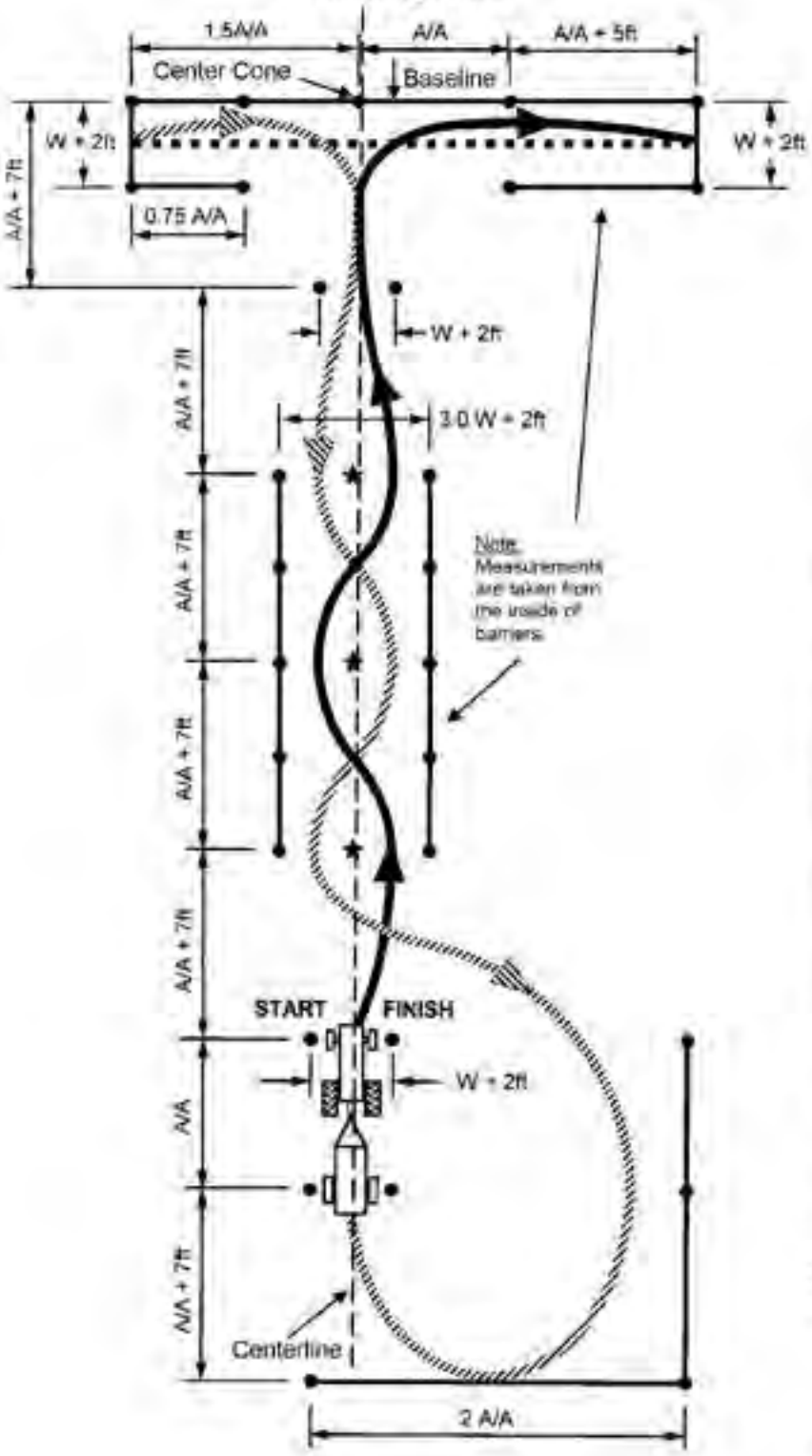
The goal of the operating skills test is to evaluate your ability to safely and efficiently start a tractor and hitch to a wheeled implement using either a drawbar or a three-point hitch. The goal of the pre-op/driving test is to test your ability to safely and efficiently drive a tractor pulling a two-wheel implement through a specified course with spaces and borders. Neither the operating skills nor pre-op/driving test activity is a competitive event; actual barrier measurements and times are not recorded. You must pass the operating skills and pre-op/driving tests each with a minimum score of 70 percent and no "automatic failure" violations. Experienced tractor operators may complete each activity within 8 to 10 minutes while less experienced operators may require more time. Any operator who cannot complete each activity within 15 minutes automatically fails the test.

You should be appropriately dressed for the operating skills and pre-op/driving tests. Snug-fitting clothes in good repair, long pants, and solid shoes with slip-resistant treads are recommended. Inappropriate dress includes baggy pants, shorts, sandals or open-toed footwear, and jewelry, including rings, watches, necklaces, and dangling earrings. You may be asked to address safety concerns or reschedule the test(s) if you are not appropriately dressed in the opinion of the community lead instructor.

Suggested skills and driving courses and evaluation forms are provided on the next few pages. Different courses are acceptable as long as the layouts include similar maneuvers.

Operating Skills and Pre-op/Driving Test Layout

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 clearly serpentine path

● — Use traffic cones, stakes, straw or hay etc. as markers

| — Use rope, bale twine, straw or hay bales to form a continuous line

Start path

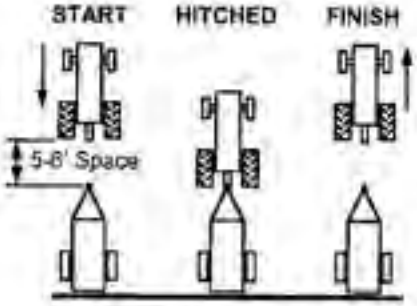
Back-up path

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.

Operating Skills Test



Note: Raise or lower implement 3 or 4 inches before starting.

Operating Skills Test Evaluation Form

Student Name: _____ Skills Examiner: _____

Test Date: _____ Test Location: _____

☐ Student is dressed appropriately.

Tractor Entry and Startup

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
1				Can demonstrate universal hand signal for _____ (instructor randomly picks).
2				Uses handholds and steps to mount tractor.
3				Adjusts seat, steering wheel (if necessary).
4				Buckles seat belt.
5				Checks major controls (PTO, hydraulics, gear shift stick) for the neutral (or PARK) position.
6				Adjusts throttle to one-third open, push clutch in, move gear selection to START position if so equipped.
7				Can demonstrate and verbalize how to safely stop the tractor.

DISCUSS UNSATISFACTORY PERFORMANCE HERE

Tractor Backup and Implement Hitching

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
8				With clutch pushed in, starts tractor, idles down throttle.
9				Selects slow/low reverse gear.
10				Slowly and smoothly backs tractor to within a few inches of implement tongue.
11				Stops tractor, shifts to neutral and set brakes, or places in PARK, reduces throttle (if moved from startup), shuts tractor off, unbuckles seat belt. **Not shutting off tractor is automatic skills test failure.**
12				Dismounts tractor by facing tractor and using handholds and steps.

DISCUSS UNSATISFACTORY PERFORMANCE HERE

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
13				Uses handholds and steps to mount tractor. Buckles seat belt, adjusts throttle to one-third open, pushes clutch in, moves gear selection to START position if so equipped, starts tractor.
14				Backs tractor to align drawbar and implement tongue holes, stops tractor, places gear in neutral and sets brakes, or places gear in PARK, reduces throttle (if moved from startup), shuts tractor off, and dismounts tractor by facing tractor and using handholds and steps. Student may need to repeat steps 13 and 14. **Not shutting off tractor is automatic skills test failure.**

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
15				Places tractor pin in hole to connect the implement, using the tractor pin safety locking device; connects safety chains (if present) to tractor.
16				Correctly connects the implement PTO, hydraulic hoses, or both.
17				Winds up jack, swings to storage position.

INSTRUCTOR INSPECTS ALL CONNECTIONS AND CORRECTS MISTAKES

Tractor Unhitching and Shutoff

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
18				Lowers jack stand, adjusts to take weight off hitch points.
19				Disconnects the implement PTO, hydraulic hoses, or both.
20				Removes tractor pin.
21				Uses handholds and steps to mount tractor.
22				Buckles seat belt, adjusts throttle to one-third open, pushes clutch in, moves gear selection to START position if so equipped, starts tractor.
23				Moves tractor forward 5 to 6 feet. **Not completely disconnecting the implement from the tractor or to move the jack stand to storage position is automatic skills test failure.**
24				Stops tractor, lowers throttle (if adjusted upward), places gear in neutral and set brakes, or puts gear in PARK, shuts tractor off, unbuckles seat belt. **Not shutting off tractor is automatic skills test failure.**
25				Dismounts tractor by facing tractor and using handholds and steps.

Not completing the skills test within 15 minutes is automatic failure.

DISCUSS UNSATISFACTORY PERFORMANCE HERE

AUTOMATIC FAILURE—PLEASE NOTE THE REASON FOR THE AUTOMATIC FAILURE.

Pre-Op/Driving Test Evaluation Form

Student Name: _____ Skills Examiner: _____

Test Date: _____ Test Location: _____

☐ Student is dressed appropriately.

Students must explain each activity as performed unless otherwise noted. Instructors should correct student errors where indicated.

Pre-operation Inspection: Student Identifies and Explains What They Are Inspecting

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
1				Checks fluid levels (oil reservoir dipstick, fuel tank cap, water/ antifreeze fill location, hydraulic fluid dipstick, etc.).
2				Checks battery condition.
3				Checks tire condition (tractor and machine).
4				Checks guards and shields (tractor and machine).
5				Checks hitch and related connections.
6				Walks around tractor and machine and looks for hazards.

DISCUSS UNSATISFACTORY PERFORMANCE HERE

Tractor Entry

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
7				Uses handholds and steps to mount tractor.
8				Buckles seat belt.
9				Adjusts seat, steering wheel.
10				Checks major controls (PTO, hydraulics, gear shift position) for the neutral or PARK position.
11				Adjusts throttle, pushes clutch in.
12				Demonstrates and verbalizes how to safely stop the tractor.

DISCUSS UNSATISFACTORY PERFORMANCE HERE

Tractor Startup and Driving: If too high a gear and/or speed is used, or if driver appears to not have complete control or awareness of tractor and implement positioning, the driver should be stopped immediately, and an automatic failure should be recorded.

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
13				Starts tractor movement smoothly, has selected low gear, using low throttle setting.
14				Drives through serpentine (or similar) course without running over or crushing barriers (a light touch or brushing is acceptable) or having to back up.

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
15				Drives into pull-in stall without running over or crushing any barriers (a light touch or brushing is acceptable) and stops within a foot of end barriers without running over or crushing them (a light touch or brushing is acceptable).
16				Backs into back-in stall within two passes, stops within a foot of end barriers without running over or crushing them (a light touch or brushing is acceptable). One pull up is acceptable.
17				Drives out of back-in stall without running over or crushing any barriers (a light touch or brushing is acceptable).
18				Drives back through serpentine course (or similar) course without running over or crushing any barriers (a light touch or brushing is acceptable).
19				Drives tractor back into middle of START/STOP position without running over or crushing any barriers (a light touch or brushing is acceptable).

Tractor Shutoff and Exit

Eval Item	Satisfactory	Unsatisfactory	Not Applicable	Skill Activities (15 minutes maximum)
20				Stops tractor, lowers throttle (if adjusted upward), places gear in neutral, and sets brakes or puts in PARK, shuts tractor off. **Not shutting off tractor is automatic driving test failure.**
21				Dismounts tractor by facing tractor and using handholds and steps.

Not completing the skills test within 15 minutes is automatic failure.

DISCUSS UNSATISFACTORY PERFORMANCE HERE

AUTOMATIC FAILURE—PLEASE NOTE THE REASON FOR THE AUTOMATIC FAILURE.

Minimum Core Content Areas and Task Sheets

In response to a request by the Hazardous Occupations Safety Training in Agriculture (HOSTA) National Steering Committee, an expert panel of agricultural safety and health professionals developed a set of Minimum Core Content Areas (MCCA) for training youth younger than age 16 who wish to work in an agricultural occupation and operate tractors and machinery (see "Training Content," below). The MCCA are based on the current United States Department of Labor Regulations in 29 CFR 570 Subpart E-1.

There are 92 task sheets provided with this curriculum. Not all of these task sheets are needed to address the required training prescribed by the U.S. DOL Hazardous Occupations Order in Agriculture. If you have limited familiarity and experience with production agriculture, work hazards, and/or agricultural safety issues, the additional task sheets will help you understand hazards associated with agricultural operations.

The 48 task sheets identified as core cover the MCCA topics and should be used to prepare for the program's written test. Written test questions come from these task sheets. To meet current requirements of this exemption, at least 24 hours should be devoted to these topics.

Contents

Training Content

The following MCCA identify the essential subject matter to be included in any training program designed to prepare youth to perform the tasks as prescribed by the "Hazardous Occupations Order in Agriculture" for employment of children younger than age 16 (U.S. DOL, effective date 1970).

1. Four hours of orientation to familiarize the student with normal working hazards.
2. Ten hours for operating a tractor over 20 PTO horsepower or connecting or disconnecting an implement or any of its parts to or from such a tractor.
3. Ten hours for operating or assisting to operate (including starting, stopping, adjusting, feeding, or any other activity involving physical contact associated with the operation) any of the following machines:
    a. Corn picker, cotton picker, grain combines, hay mower, forage harvester, hay baler, potato digger, or mobile pea viner
    b. Feed grinder, crop dryer, forage blower, auger conveyor, or the unloading mechanism of a no-gravity-type self-loading wagon or trailer
    c. Power post hole digger, power post driver or non-walking rotary tiller

Note: The order and organization in which the MCCA are taught is left to the discretion of the instructor. The items in parentheses are suggested topics and not inclusive of those that can be taught under any respective MCCA.

Programs that address GENERAL agricultural safety shall incorporate the following MCCA (four hours):

G1. Applicable state and federal regulations (OSHA, U.S. DOL, WPS)
G2. Characteristics of the safe farm worker (dress, attitude, behavior, developmentally appropriate)
G3. Mechanical hazards (pinch points, pull-ins, wrap points)
G4. Chemical hazards (labeling, pesticide restrictions, petroleum products)
G5. Electrical hazards (grounding/GFCIs, overhead powerlines, underground power)
G6. Livestock hazards (working prohibitions, zoonotic diseases, animal behavioral characteristics)
G7. Structural hazards (working prohibitions, falls, grain bins, silos)
G8. Understanding and use of universal hand signals
G9. Environmental hazards (weather, insects, noise, terrain)
G10. ATVs and utility vehicles
G11. Personal protective equipment (PPE)
G12. First aid and emergency response

Programs that address safe TRACTOR operation shall incorporate the following MCCA (10 hours):

T1. Tractor controls, instruments, and gauges
T2. Tractor operational systems (fuel, electrical, hydraulics)
T3. Tractor safety systems and features (seatbelt, ROPS, master shield, safe starting systems, enclosed cabs)
T4. Tractor pre-operational check (fuel, tires, air, water, oil)
T5. Operator's manuals (tractor specifications, maintenance, warnings, controls)
T6. Tractor operating procedures (start, move

forward/backward, stop, mounting/ dismounting)

T7. Tractor operational hazards (stability, fires, runovers, slips/falls, extra riders, PTO)

T8. Public road use (operator age, lighting and marking, equipment width and length, highway regulations)

Programs that address MACHINERY safety shall incorporate the following MCCA (10 hours):

M1. Operator's manuals (specific machines)

M2. Implement power transfer (PTOs, hydraulic, mechanical, electrical)

M3. Implement hitching (three-point, front mounted, hydraulics, drawbar)

M4. Machine operating hazards (corn picker, cotton picker, grain combines, hay mower, forage harvester, hay baler, potato digger, mobile pea viner, feed grinder, crop dryer, forage blower, auger conveyor, the unloading mechanism of a no-gravity-type self-loading wagon or trailer, power post hole digger, power post driver, or non-walking rotary tiller)

M5. Materials handling (large round bales, flowing grain, safe lifting)

Testing Procedures

Step 1. Written Exam

The written exam shall be a 50-question multiple-choice/true or false test based on the MCCA. If passed, student moves to Operating Skills test; if failed, student reviews lessons, re-takes written test.

Step 2. Operating Skills Test*

Upon passing, student moves to Step 3; upon failure, student reviews and practices operating skills, and retakes the test. Skills include:

◊ Starting tractor
◊ Backing up tractor
◊ Connecting tractor to a machine (PTO, hydraulics, electrical, hitch, etc.)
◊ Disconnecting machines
◊ Stopping and parking tractor

Step 3. Pre-operation and Driving Skills Test*

The pre-operation and driving skills test is normally done with one tractor for both parts.

Pre-operation Skills

Pre-operational checks include:

◊ Checking of oil, fuel, cooling fluids, etc.
◊ Visual inspection of tires, shields, guards, fasteners, leaks, etc.
◊ Demonstrating universal hand signals (ASAE)
◊ Safe mounting and dismounting, adjustment of the operator's station, location of controls, etc.

If student passes the pre-operation test, then they continue on with driving skills test; if student fails, then they review and retake the pre-operational test.

Driving Skills

The student operates a tractor and machinery through a serpentine driving course, forward and reverse operation, and back in and pull out of prescribed space. Upon passing, student takes score sheet to community lead instructor; if student fails, then they review and practice driving skills and retake driving skills test.

*Students who score 69 percent or below may be able to retake the test that same day if extra tractors and instructors are on hand. However, if that is not possible, the student will need to reschedule the testing for another day.

Note: It is recommended that the written exam and operating skills and pre-op/driving tests be given within 60 days of each other. If a retake of the written test is needed, a new test is generated.

1

Section One
Introduction

The Work Environment

Learning Goals

- Understand the variability of agriculture and how this relates to farm safety and health
- Identify factors and situations that contribute to agricultural hazards and risks

Related Task Sheets

- 1.2: Safety and Health Regulations
- 1.2.1: Hazardous Occupations Order in Agriculture

Agriculture is more diverse than most people think.

Introduction

Work on a farm or ranch is different from work in other industries. Many of these differences increase your chance of being injured.

This section reviews why and how working on a farm or ranch can be different from other jobs, and why these differences increase hazards and risk of injury.

Farm Differences and Safety

A farm is defined by the U.S. Department of Agriculture as any place from which $1,000 or more in agricultural products were produced and sold or normally would have been sold.

Farms and ranches can vary in the number of acres in production. In 2017, 70 percent of all farms were on 179 acres or fewer, and just over 75 percent of all farms sold less than $50,000 in

Figure 1.1. Agricultural work is done under changing conditions. Often the work is done hurriedly to beat the approaching storm. Safety must still be a major priority. Credit: Michael Houtz, Penn State Extension

agricultural products. Only 4 percent of farms produced 69 percent of the total agricultural products sold.

Farmers and ranchers produce a wide variety of products ranging from crops to livestock. Field crops include corn, soybean, and wheat. Other crops produced include nuts, fruits, and vegetables. Livestock production may include beef, dairy, hog, sheep, and poultry. Some may specialize in llamas, buffalo, mink, fish, or bees. Many farms and ranches engage in diversification by producing a combination of different crops, livestock, and/or services. Farming and ranching activities can occur in a variety of terrain and weather conditions. Some activities may involve operating equipment on flat, level surfaces, while other activities will likely be conducted on slopes. Some work occurs where there are buildings that protect against the cold, wind, snow, or rain; however, most work will expose you to heat, rain, cold, and wind.

All of these differences make it hard to find universal ways to reduce your chance of injury. However, planning and preparation will help you avoid the hazards and risks associated with this important work.

Farm or ranch work includes many characteristics and factors that increase the risk of injury.

Unique Characteristics

There are many ways to organize the information that describes why farm or ranch environments are different from other types of work environments. One of the simplest ways is to list the four main characteristics that make these environments 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. Most are operated by family members using labor without age-related restrictions
4. Little government regulation of work hazards and risks (except with pesticides)

The combined effect of these four characteristics contribute to production agriculture being one of the most hazardous industries.

Factors That Make It Difficult to Improve Safety

The four main characteristics listed above are simple to learn, but there are factors that make it difficult to understand why agriculture remains so hazardous. Hazards and risks continue to be difficult to eliminate or control. The factors that influence farm/ranch work and risk of injury are:

- Environmental
- Personal
- Work activity
- Social, economic, and political

These factors are explained in greater detail in the following tables. Review these tables for an understanding of why so many hazards and risks remain a part of farming and why there are so many injuries.

Environmental Factors That Influence Farm Work and Risk of Injury

Factor	Risk
Weather	Farm or ranch work must often be completed regardless of weather extremes.
Work sites	Work sites commonly overlap with residences.
Emergency services	Emergency services are not readily available, which often results in a delayed response due to isolation of the work site.
Isolation of work	Coworkers are often not within eyesight or hearing distance when trouble occurs.
Personal hygiene	Personal hygiene is often required and made available in other occupations. However, it is up to individual workers in agriculture.
Environmental hazards (noise, vibration, lighting, dust, etc.)	Hazards and exposures are not monitored or regulated in agriculture like they are in most hazardous industries.

Personal Factors That Influence Farm Work and Risk of Injury

Factor	Risk
Young workers	Youth younger than 16—and sometimes as young as five—years old 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 continuing to work in high-risk situations.
Minimal physical limits	Initial physical exams or minimum performance requirements are often required to begin or 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 available 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	It is difficult to provide health and safety services because of geographic dispersion and mobility of the workforce.

Factor	Risk
Diverse operator characteristics	Operators' education and experience can vary; some work full time, others work significant hours off the farm, and some work full time off the farm with farming or ranching serving as supplemental income.

Work Activity Factors That Influence Farm Work and Risk of Injury

Factor	Risk
Work hours	Work weeks of 60 to 80 hours are common in agriculture.
Labor and management functions	Usually these jobs represent separate functions in other hazardous occupations, but not in farming or ranching.
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 and ranchers often learn their trade by observation and experience.
Holidays and vacations	Days off are normal for most occupations, but not for the farm or ranch worker.
Labor demands	Operations frequently make use of any temporarily available labor, such as migrants, spouses, children, friends, visitors, new acquaintances, and off-the-street employees.
Uncertainty	Farming and ranching are characterized by an uncertain financial future. Weather, fast-spreading plant and animal disease, broad economic policy, and unexpected world events can result in financial hardship.
Agriculture production	Size and type of farm and the technology used can vary greatly, which makes grouping the types of modern agriculture difficult.

Social, Economic and Political Factors That Influence Farm Work and Risk of Injury

Factor	Risk
Lifestyle vs. occupation	Farming is commonly viewed as a "way of life" rather than as an occupation. Some engage in production agriculture as a hobby or lifestyle statement.
Agrarianism	This is a term applied to agriculture that says society is in debt to farmers because they suffer so that a democratic society can prosper.
Childcare	Childcare is often not available, practical, or affordable in rural areas, which results in parents babysitting infants, toddlers, preschoolers, and other children while completing farm work.
Occupational safety and health legislation	New standards and regulations often exempt production agriculture because of a combination of a lack of practicality to farming and ability to enforce the standards or regulations, and the burden on producers 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 that little can be done about safety and health except to be careful.
Market forces	Market demands often set the price of commodities produced. Farmers or ranchers often cannot add the costs of safety and health to products to recoup costs.
Self-reliance for safety	Individuals rely primarily 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 are taught 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 or ranching.

Safety Activities

1. How many of these characteristics and factors are present on the farms where you live or work? Discuss these with your parents, instructor, or mentor.
2. Show the tables above to one or two area farmers and have them identify how many factors may have contributed to a farm work injury to themselves or someone on their farm.
3. 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 these with your parents, instructor, or mentor.

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Safety and Health Regulations

Learning Goal

◊ Become aware of the regulations that affect agricultural workers

Related Task Sheets

◊ 1.2.1: Hazardous Occupations Order in Agriculture
◊ 1.2.2: Occupational Safety and Health Act
◊ 1.2.3: Workers' Compensation Laws
◊ 1.2.4: Agricultural Worker Protection Standard
◊ 1.2.5: State Vehicle Codes
◊ 1.3: Environmental Regulations
◊ 4.14: Operating the Tractor on Public Roads

Introduction

Fewer safety regulations are applied to agriculture than to hazardous occupations. Safety regulations are intended to help keep you and your coworkers from being hurt or killed while on the job. Employers who do not follow these regulations may be fined and/or imprisoned.

This section explains safety and health regulations that are important to youth who plan to work in the field of agriculture.

Hazardous Occupations Order in Agriculture

Since 1969 the U.S. Department of Labor has declared many agricultural tasks to be hazardous for youth younger than age 16.

Figure 1.2.a. Safety and health regulations govern not only agricultural equipment in traffic situations but also the protection of young people as they work in the field of agriculture. Safety and health regulations are designed to protect you, not prevent you from learning new skills or earning money. Credit: Penn State Extension Ag Safety Team

Employment of youth under age 16 for these tasks is illegal. However, specific exemptions do exist. The law does not apply to youth younger than age 16 who are employed, either with or without compensation, by their parents or legal guardian.

As part of this declaration, a procedure was established by the Department of Labor so that youths 14 and 15 years of age could be exempted under a student-learner program or through completion of an appropriate training program. The training program exemption applies to the operation of agricultural tractors and/or specific types of farm machinery. This exemption is explained in more detail in Task Sheet 1.2.1.

Penalties for subjecting youth to hazardous occupations are relatively strict. Youth are not penalized for the infractions, but their employer can be. Employers can be fined over $12,000 for the first violation of child labor standards. See the U.S. Department of Labor website for more information on current penalties that can be assessed to employers.

Occupational Safety and Health Act

Important points about Occupational Safety and Health Administration (OSHA) regulations are sometimes confusing or misunderstood. An employer/employee relationship has to exist for OSHA regulations to apply to a business or operation. This means that if a farm operator uses only their own or family labor or has fewer than 11 employees, OSHA has no jurisdiction to conduct inspections or enforcement in that operation.

The Occupational Safety and Health (OSH) Act became effective in 1971 but has had little direct influence on most agricultural operations since October 1976. That is when Congress restricted OSHA from expending any funding to enforce rules on farms employing fewer than 10 employees. This restriction, known as the "small farm exemption," has been in effect since 1976.

This does not mean that farms with 10 or fewer employees are exempt from OSHA's requirements; OSHA just cannot inspect those farms for compliance or issue compliance citations. Although these two statements appear to be similar, the differences could be significant in a court of law.

OSH Act = Occupational Safety and Health Act

Workers' Compensation Laws

Businesses, including farm operations, often pay into a workers' compensation insurance fund to cover medical and rehabilitation costs of workers injured on the job. Since the cost of this program is high, employers must be sure that employees are trained in safety and have a safe work attitude.

Concerns about injury and workers' compensation costs may cause your employer to be especially diligent about your safety behavior. Do not feel that you are being singled out as not being able to work safely.

Worker Protection Standard

The U.S. Environmental Protection Agency (EPA) implements regulations to protect human health and the environment, including the regulations to ensure pesticide workers are not exposed to the hazards associated with applying and handling pesticides. EPA's Agricultural Worker Protection Standard (WPS) establishes practices aimed at reducing the risk of pesticide poisonings and injuries among agricultural

workers and pesticide handlers. The WPS offers protection to over 2 million people who work with pesticides at over 600,000 workplaces. The WPS contains:

- Requirements for pesticide safety training
- Notification of pesticide applications
- Use of personal protective equipment
- Restricted-entry intervals following pesticide application
- Decontamination procedures and supplies
- Emergency medical assistance recommendations

The WPS regulates the workplace and promotes guidelines for the safety and health of workers. These standards were revised in 2015. For current information, see the EPA website.

WPS = Worker Protection Standard

Insurance Company Requirements

Some insurance companies have policies to assist in reducing injuries affecting their customers. Usually this is based on studies they make of customers' claims (actuarial studies). Since agriculture is known to be a particularly hazardous occupation, some insurance companies may view the employment of young workers as a liability risk. Some farmers have been notified not to use young people for certain jobs because of the possibility of increased insurance premiums. Additionally, if you are going to work for a farmer, you or your parents may want to ask if the farmer has insurance coverage in case of an injury.

Vehicle Codes

Most state vehicle codes will contain provisions that apply to the movement of agricultural equipment on public roadways. The rules and regulations vary greatly from state to state. Check your state vehicle code for information regarding the following points:

- Definition of "public road or highway." Your state may define highway as" the entire width between the boundary lines of every highway publicly maintained when any part is open to the use of the public for purposes of vehicle travel." Any road, including shoulders and berms, open to the public is referred to as a highway.
- Your state's vehicle code may have a statement that requires all persons who operate motor vehicles on a highway to have a license unless specifically exempted elsewhere in the code. Exemptions to the licensing requirement may show some language similar to the following: "Persons 14 or 15 years of age are restricted to the operation of implements of husbandry on one- and two-lane highways which bisect or immediately adjoin the premises upon which such person resides." In other words, 14- and 15-year-old youths can operate farm tractors only on public roadways that bisect or adjoin their place of residence.

Also consider these points:

- Use of the slow-moving vehicle (SMV) emblem rules is fairly consistent nationwide. The SMV emblem must be used properly (see Task Sheet 4.14).
- Lighting and marking regulations can be found in most state vehicle codes (see Task Sheet 4.14.1).
- Load restrictions for width, length, weight, and number of towed implements and use of safety chains can be found in vehicle codes.
- State vehicle codes may also address trucks licensed for farm use only, riders as passengers on the bed of a truck, and farm use of ATVs (all-terrain vehicles).

Check with your local governing authorities to learn which traffic laws apply in your state. You must follow the vehicle code in your state. Your state highway patrol can be a source of information for you; contact your local state police headquarters.

Be sure to check your state's motor vehicle code!

Safety Activities

◊ Use the Internet to search for information about the federal safety regulations mentioned in this task sheet. Find additional details on how the regulations may affect agricultural workers.

◊ Talk to your parents' insurance agent and ask about injury and liability concerns that they may have regarding your employment in agriculture.

◊ Complete the following table by writing down tasks you have done, marking whether or not the task was covered by federal safety regulations, and noting what hazard you encountered. Have you done any jobs/tasks that may be prohibited for youth your age?

Figure 1.2.b. Know the rules of the road! You must follow these rules when operating farm equipment on public roads. Credit: Penn State Extension Ag Safety Team

Tasks I Have Completed	Is the Task Covered by Federal Safety Regulations?	Safety Hazard of the Task

References

Occupational Safety and Health Administration "Youth in Agriculture" website, **www.osha.gov/SLTC/youth/agriculture/ index.html**.

U.S. Environmental Protection Agency "Pesticide Worker Safety" website, **https://www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps**.

Hazardous Occupations Order in Agriculture

Learning Goals

- Understand the Fair Labor Standards Act and Hazardous Occupations Order in Agriculture
- Understand the reason for Hazardous Occupations Safety Training in Agriculture

Related Task Sheets

- 1.1: The Work Environment
- 1.2: Safety and Health Regulations
- 1.2.4: Agricultural Worker Protection Standard

Introduction

Some states may have more regulations and/or enforcement applied to youth working in agriculture, so be sure to check with local governing authorities. When federal and state standards differ, the regulations that are more stringent to youth will apply.

The Exemptions

As part of the U.S. Department of Labor's Fair Labor Standards Act, a declaration known as the Hazardous Occupations Order in Agriculture established a procedure whereby youth 14 and 15 years of age who complete an approved tractor operations or tractor **and** machine operations program could be exempted from certain portions of the regulation. This exemption specifically addresses the following occupations:

1. Operating a tractor of over 20 PTO horsepower or connecting or disconnecting an implement or any of its parts to or from such a tractor
2. Operating or assisting to operate (including starting, stopping, adjusting, feeding, or any other activity involving physical contact associated with the operation) any of the following machines:
   a. corn picker, cotton picker, grain combine, hay mower, forage harvester, hay baler, potato digger, or mobile pea viner
   b. feed grinder, crop dryer, forage blower, auger conveyor, or the unloading mechanism of a non-gravity-type self-unloading wagon or trailer
   c. power post hole digger, power post driver, or non-walking rotary tiller

By completing the tractor operations training program, youth are **only** allowed to operate a tractor with no powered equipment attached. A youth would need to complete the tractor **and** machine operations training program to perform field work using a tractor with power equipment attached.

The law defines "agriculture" as "farming in all its branches, including preparation for market, delivery to market, delivery to storage, or to carriers for transportation to market." This statement allows a properly trained youth to haul produce and other products to markets, between farms, and so forth. Provisions in your

state vehicle code may preclude this activity by 14- and 15-year-olds.

Prohibited Work

Unless employed by a parent or legal guardian, the order prohibits youth under the age of 16 from the following tasks (no exemptions):

- ◊ Driving a vehicle to transport passengers or riding on a tractor as a passenger or helper
- ◊ Working inside certain agricultural storage structures with hazardous atmospheres or packing a horizontal silo
- ◊ Working with toxic agricultural chemicals
- ◊ Handling or using explosives and anhydrous ammonia

Student-Learner

Under a written agreement following certain conditions, student-learners in a bona fide vocational agricultural program may work in occupations listed in paragraphs 1 through 6 under 570.71 (a) of the U.S. Department of Labor in the Agriculture Hazardous-Occupations Order (subpart E-1 of 29 CFR, Part 570) that provide all of the following conditions:

1. The student-learner is enrolled in a course of study and training in an education training program in agriculture under a recognized state or local educational authority or in a substantially similar program conducted by a private school.
2. Such student-learner is employed under a written agreement that provides the following:
   a. The work of the student-learner is incidental to the training.
   b. Such work shall be intermittent, for short periods of time, and under the direct and close supervision of a qualified and experienced person.
   c. Safety instruction shall be given by the school and correlated by the employer with on-the-job training.
   d. A schedule of organized and progressive work processes to be performed on the job shall have been prepared.
3. Each such written agreement shall contain the name of the student-learner and be signed by the employer and a person authorized to represent the educational authority or school.
4. Copies of each agreement shall be kept on file by both the employer and either the educational authority or the school.

According to the regulation, this exemption is revoked in any individual case if reasonable precautions have not been taken to ensure the safety of minors engaged in the program.

4-H and Vocational Agriculture Training

The tractor operations training program is designed to prepare youth to perform tasks as prescribed by the Hazardous Occupations Order in Agriculture (HOOA) for employment of children under 16 years of age. The student learner will need to successfully complete 4 hours of orientation to familiarize the student with working hazards, 10 hours of operating a tractor over 20 PTO or connecting or disconnecting an implement to or from a tractor, and 10 hours for operating machinery defined by HOOA.

Workers Younger Than Age 14

These regulations do not permit youth younger than age 14 to complete the exemption training. This means youth younger than age 14 cannot be hired by an agricultural employer to complete jobs declared hazardous by the Department of Labor.

Nonhazardous Occupations

Not all agricultural jobs are deemed hazardous for young people. Many tasks on farms are not considered hazardous by the Department of Labor and are permitted under the Fair Labor Standards Act. These include but are not limited to:

- ◊ Loading and unloading trucks
- ◊ Operating small tractors (under 20 horsepower)
- ◊ Picking vegetables and berries
- ◊ Placing vegetables and fruits on conveyors or into boxes
- ◊ Raising and caring for poultry
- ◊ Milking cows
- ◊ Cleaning barns, equipment, and storage buildings
- ◊ Mowing lawns
- ◊ Riding, driving, or exercising horses
- ◊ Handling irrigation pipes
- ◊ Riding on a mechanical transplanter

When a federal regulation and a state regulation conflict, the most stringent regulation is enforced. Check with state authorities when in doubt.

Safety Activities

1. Make a list of possible jobs or tasks for the farm or ranch. How many of them would be included in the list of activities prohibited by the Hazardous Occupations Order in Agriculture for youth younger than age 14?
2. Discuss with your classmates or interested friends why you think some tasks have been included in the Hazardous Occupations Order in Agriculture list while other tasks have not.

Resources

Occupational Safety and Health Administration "Youth in Agriculture" website, **www.osha.gov/SLTC/youth/agriculture/index.html**.

U.S. Department of Agriculture website, **www.usda.gov**.

U.S. Department of Labor website, **www.dol.gov**.

Occupational Safety and Health Act

Learning Goal

◊ Become aware of OSHA regulations that affect agricultural work

Related Task Sheets

◊ 1.2: Safety and Health Regulations
◊ 3.1: Mechanical Hazards
◊ 3.6: Electrical Hazards
◊ 3.8: Confined Spaces
◊ 4.12: Tractor Stability
◊ 4.14: Operating the Tractor on Public Roads
◊ 4.14.1: Lighting and Marking

Introduction

The Occupational Safety and Health Administration (OSHA) is an agency created to save lives, prevent injuries, and protect the health of all American workers. After OSHA's establishment, workplace fatalities and instances of injury and illness have decreased, while workforce numbers and job sites have been on the increase.

This section examines how OSHA affects agricultural workplaces. The entire law cannot be presented here. For more information, go to the OSHA website or visit with your local or regional office.

OSHA's Jurisdiction

An employer/employee relationship has to exist in order for OSHA to apply to a business or operation. If a farm operator uses only their own

Fig. 1.2.2.a. The business of farming presents daily exposure to hazards. Livestock, machinery, and the environment present safety concerns. OSHA regulations may limit inspections of farms, but safe work habits and workplace conditions must be made a daily concern. Credit: Michael Houtz, Penn State Extension

or family labor, OSHA does not apply. Since 1976 Congress has restricted OSHA from expending any administrative funds to enforce rules and regulations on any farm with 10 or fewer employees. This restriction is known as the "small farm exemption." However, OSHA regulations still apply to small farms, but no enforcement or inspections can take place. Legally, OSHA covers all farms, but the agency cannot inspect farms with 10 or fewer employees or perform enforcement activities. One important reason for understanding that small farms still fall under OSHA is that, in a court of law, OSHA rules and regulations may be used to identify safe and unsafe conditions on the farm for civil or criminal charges.

General OSHA Rules

A general rule of OSHA requires employers to provide employees a place of employment that is free from recognized hazards that have caused or are likely to cause death or serious injury. A second part of this rule states that employers must comply with OSHA safety and health standards. These two rules apply to small farms as well as larger farms. This could also be important in a court of law if an employee is killed or injured while performing farm work.

OSHA also requires that each employee comply with safety and health rules, such as shutting off power to equipment before working on any machine, wearing personal protective equipment, and informing employers of hazards. An employee who is injured or causes injury to another worker by deliberately acting in an unsafe way may be held legally responsible per OSHA standards.

OSH Act = Occupational Safety and Health Act. To study the law in detail, go to www.osha.gov.

Agriculture and OSHA

Agricultural operations are covered by several Occupational Safety and Health standards, including Agriculture (29 CFR 1928), General Industry (29 CFR 1910), and the General Duty Clause. The OSHA agricultural standards that are most important to tractor and machinery operators include regulations for Roll-over Protective Structures (29 CFR 1928 Subpart C), Guarding of Farm Field Equipment, Farmstead Equipment, and Cotton Gins (29 CFR 1928 Subpart D 1928.57), and Specifications for Accident Prevention Signs and Tags (29 CFR 1910 Subpart J 1910.145). These requirements are discussed in more detail in the following sections.

Roll-over Protective Structures

Roll-over Protective Structure Requirements

Since 1976, roll-over protective structures (ROPS) have been required on all tractors operated by employees. In addition, OSHA regulations state that employers are also required to provide safe operating instructions to employees at initial assignment and on an annual basis thereafter. Employers are to ensure that seatbelts are used by their employees on ROPS-equipped tractors. Exempted from the standards are low-profile tractors used in orchards, greenhouses, and other buildings.

Operating Instructions

The following instructions are to be provided to the employee at their initial assignment and at least once a year thereafter:

- If the tractor has a ROPS, use the seat belt.
- Avoid ditches, embankments, and holes.
- Reduce speed when turning, crossing slopes, and on rough, slick, or muddy surfaces.
- Avoid slopes that are too steep for safe operation.

◊ Exercise care at row ends, on roads, and around trees.
◊ Do not permit extra riders on the tractor.
◊ Operate the tractor smoothly with no jerky starts, turns, and stops.
◊ Hitch only to the drawbar and recommended hitch points.
◊ Set the brakes and use the park lock if available when the tractor is stopped.

Specifications for Accident Prevention Signs and Tags

This OSHA standard provides specifications for the design, application, and use of signs or symbols to indicate and define specific hazards that could harm workers. The slow-moving vehicle emblem applies to tractors and machinery.

Slow-Moving Vehicle Emblems

The OSHA Accident Prevention Signs and Tags regulation defines use of the slow-moving vehicle (SMV) emblem. The SMV emblem must be displayed at the rear of the tractor and/or tractor implement combination to warn others that the farm vehicle is incapable of traveling at more than 25 mph. See Task Sheet 4.14 for more information.

Properly use the SMV emblem. Be sure it is clean and visible if you are required to operate agricultural vehicles that travel less than 25 mph on public roads. In some states, it is illegal to improperly use SMV emblems as driveway and mailbox markers.

Some agricultural vehicles traveling at speeds greater than 25 mph may be required to be marked with a speed identification symbol that complies with ASABE (American Society of Agricultural and Biological Engineers) standards.

Farm Field Equipment, Farmstead Equipment, and Cotton Gin Guarding

Moving Parts Guarding and Instruction

Guarded machine parts prevent the worker from being exposed to risks of entanglement and dismemberment. OSHA Machine Guarding standards require the following:

◊ All farm field and farmstead equipment, regardless of date of manufacture, must be provided with PTO guarding.
◊ All power transmission components on new field and farmstead equipment must be provided with nip point guarding. Nip points are pinch points on gears, belts, and pulleys (see Task Sheet 3.1).
◊ Means must be provided to prevent accidental application of electrical power to farmstead equipment. Electrical power devices must be locked out or tagged out during maintenance and service of the equipment (see Task Sheet 3.6).

Employee education is also part of this OSHA standard. The law states, "Employees must be instructed in the safe operation and servicing of all equipment which they operate or will operate." The following instructions must be given at the time of assignment and at least once a year:

◊ Keep all guards in place when the machine is in operation.
◊ Permit no riders, other than those necessary for instruction or assistance, on farm field equipment.
◊ Stop the engine, disconnect the power source, and wait for all machine movement to stop before servicing, adjusting, cleaning, or unclogging the equipment except where the machine must be running to be serviced or maintained. If the machine must be running to do such tasks, then employees are to be

instructed in all steps and procedures to safely do the service or maintenance.

- ◊ Clear the machine area before starting the engine, engaging the power, or operating the machine.
- ◊ Lock out electrical power before working on farmstead equipment.

Ignorance is no excuse for violating safety laws.

Figure 1.2.2.b. OSHA regulations specifically cover ROPS, seat belts, and guarding of moving machinery parts. Be responsible and know what is required. Credit: NAGCAT

Confined Spaces

Although OSHA regulations for confined spaces do not apply to agriculture, the general duty clause expresses that hazards such as confined spaces (silos, manure pits, grain bins and elevators, and controlled atmosphere storages) must be explained to the employee. No worker should be exposed to risk of injury or death while working within a confined space. For more information, see Task Sheet 3.8 and the OSHA website for 29 CFR 1910 Subpart J 1910.146.

Figure 1.2.2.c. Workers must be instructed about the dangers of working in a confined space before they begin a task. Confined spaces may expose workers to deadly gases, entrapment, or suffocation. Credit: Penn State Extension Ag Safety Team

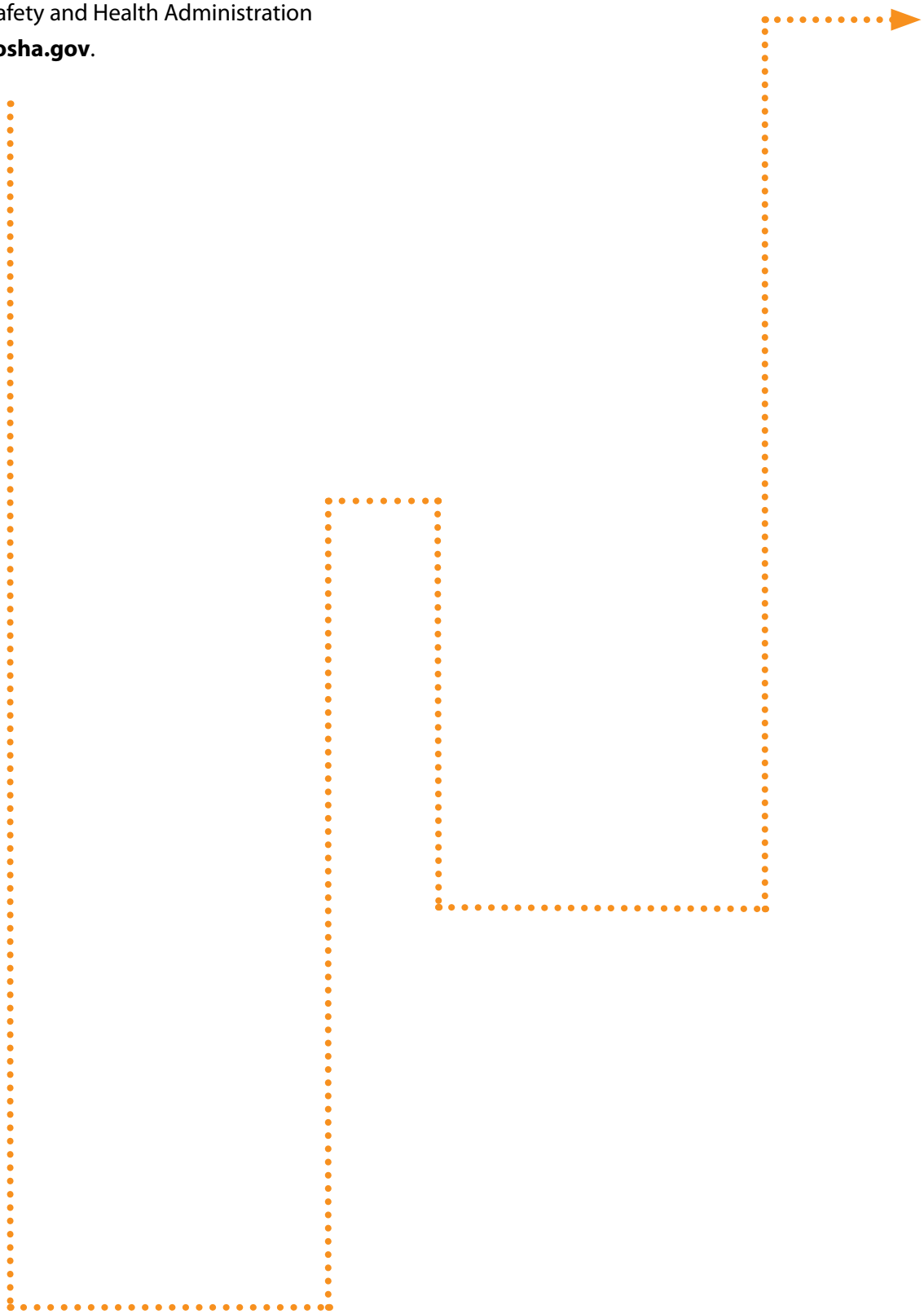
Safety Activities

1. Search the OSHA website for information regarding agricultural operations. Report on specific training and instructions employers must provide to employees about the use of tractor and ROPS, machine guarding, SMV emblems, and field sanitation.
2. What percentage of the farms in your community employ more than 10 employees? Hint: Do a survey of the total number of farmers in your community. This is the denominator. The numerator will be the total number of farms employing more than 10 employees. Divide the number of farms with more than 10 employees into the total number of farms. Make the calculation.
3. Form as many words as you can from the title "Occupational Safety and Health Act." If you can, include words or phrases that are related to safety, risk, or injury (for instance, "safe" and "unsafe action"). Make your list here or on a separate sheet of paper. Score yourself as an expert in recognizing safety if you get more than 10 words dealing with safety, risk, or injury.

References

Murphy, D. J. *Safety and Health for Production Agriculture*. St. Joseph, MI: American Society of Agricultural Engineers, 1992.

Occupational Safety and Health Administration website, **www.osha.gov**.



Workers' Compensation Laws

Learning Goal

◊ Understand workers' rights to compensation when injury and disability and death have occurred at the workplace

Related Task Sheet

◊ 1.2: Safety and Health Regulations

Introduction

Workers' compensation laws provide financial help to workers injured on the job no matter who is at fault.

This task sheet discusses workers' compensation laws. These laws may differ between states. Federal workers' compensation laws apply only to federal employees.

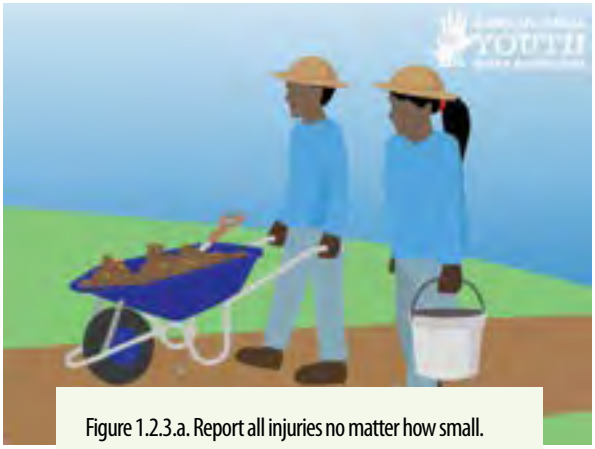


Figure 1.2.3.a. Report all injuries no matter how small. Credit: National Children's Center for Rural and Agricultural Health and Safety

The Law

Workers' compensation is an insurance program set up to provide injured workers with certain compensations to assist them in the event of lost wages due to a work-related injury. The legal requirement of coverage may depend on several factors, such as:

◊ Type of work performed
◊ Number of employees or annual payroll size

How the Law Works

The state in which you work may or may not require the employer to carry coverage. However, there are benefits to the employer if they are able to opt into the program.

The following information is important for an agricultural employee:

◊ Compensation for injury, disability, and death is provided as a benefit to employees and their surviving family members by law.
◊ Employers and employees pay into the workers' compensation fund of their home state according to the hours of employment provided.
◊ Claims are filed with the employer and medical attention is provided by approved providers.
◊ Depending on the extent of the injury, compensation during recuperation is paid, but it is limited to two-thirds of the statewide average weekly wage.
◊ Medical checkups may be required to determine the return-to-work date or how long the benefits will be paid.

Be sure to check the laws concerning workers' compensation that are specific to your state. Most states have a minimum level of hours worked or pay received before workers' compensation takes effect.

Workers' compensation laws protect the worker.

What You Should Expect

As a beginning worker, the following points will help you understand how workers' compensation relates to your participation in a work environment:

- ◊ Notification of employees' rights and filing of claims should be clearly posted for employees to see.
- ◊ The notice should state, "Remember, it is important to tell your employer about your injuries."
- ◊ Report all injuries no matter how small. For example, a deeply embedded splinter can become infected. This could lead to blood poisoning and result in emergency medical treatment and/or amputation.
- ◊ Injuries must be reported within 72 hours of the occurrence to be covered by compensation.
- ◊ If the worker has suffered some disability, they have the right to be transferred to a different job or a modified job when they return to work.

Note: These points do not represent legal opinions. Filing a claim may alter the procedures you will encounter.

No matter how big or how small the injury, notify your employer when you are injured!

Safety Activities

1. Locate and read a "Workers' Compensation Notice" at your place of employment. If you are not employed, ask any employer to show you one of these documents.
2. Conduct a survey of farm employees or classmates employed by farmers to determine if any of them have received workers' compensation due to injuries in the workplace.
3. Visit your state government website to research the workers' compensation laws. The law may be several hundred pages long; therefore, do not print it.
4. Complete an internet search using "workers' compensation" as keywords.
5. Explore options and requirements for workers' compensation in your state.

Agricultural Worker Protection Standard

Learning Goals

- Become aware of the risks of exposure to agricultural pesticides
- Gain knowledge of the WPS, which is designed to reduce personal exposure to agricultural pesticides

Related Task Sheets

- 1.2: Safety and Health Regulations
- 1.2.1: Hazardous Occupations Order in Agriculture
- 2.5.1: Heat and Sun
- 2.10: Personal Protective Equipment
- 3.5: Agricultural Pesticides

Introduction

The Agricultural Worker Protection Standard (WPS) regulation requires employers to take steps to reduce the risk of pesticide-related illness and injury to employees who use or are potentially exposed to pesticides.

This section discusses the WPS.

Farm workers younger than age 18 years who are not immediate family members of the owner of the agricultural establishment may not apply or handle restricted-use pesticides or early entry under the WPS (see Task Sheet 1.2.1 for allowable work tasks).

However, youth farm workers may come into contact with pesticide-treated areas in the course of their daily work. Understanding the WPS will explain the need for safety when exposure to agricultural chemicals exists.

The Standard

Agricultural workers and pesticide handlers must be provided information about pesticide safety. There are no exemptions based on the size of the farming operation. WPS requires certain information to be provided to workers and handlers.

1. Ensuring employees will be informed about exposure to pesticides. This may include but is not limited to:
   - Pesticide safety training for workers and handlers
   - Access to specific information for workers and handlers, including:
     - Pesticide applications on the establishment
     - Safety data sheets for pesticides applied on the establishment
     - Pesticide safety information (poster) that includes emergency information
   - Access to labeling information for pesticide handlers and early entry workers
2. Ensuring employees will be protected from exposures to pesticides. This may include but is not limited to:
   - Keeping workers and other people out of areas being treated with pesticides
   - Keeping workers and other people away from pesticide application equipment (out of the application exclusion zones) during applications

- ◊ Having handlers suspend applications if workers or people are near pesticide application equipment (in the application exclusion zone) during applications

3. Addressing pesticide exposures that employees may experience and mitigating these encounters. This may include but is not limited to:
   - ◊ Providing supplies, including a sufficient supply of water, soap, and towels, for routine washing and emergency decontamination
   - ◊ Providing emergency assistance by making transportation available to a medical care facility in the case of a pesticide injury or poisoning, and providing information about the pesticide(s) to which the person may have been exposed

As an employee, you may see or be informed of pesticide safety information even though you are not eligible to apply the pesticides. If you are asked to apply restricted-use pesticides, inform your employer that you are ineligible for the task.

You may have to water, prune, weed, or harvest a pesticide-treated area. Be aware of what the WPS means.

The Label Is the Law!

It is a violation of federal law to use a pesticide product in a manner that is inconsistent with its labeling. Safety Data Sheets (SDS), formerly Material Safety Data Sheets (MSDS), are supplement to pesticide labels. These sheets provide information for consumers about products ranging from paints and solvents to medicines and pesticides, and provide the consumer with much information regarding the product they have purchased.

- ◊ SDS should be kept on file with pesticide labels.
- ◊ Training should be provided to workers annually.
- ◊ The WPS designates procedures to prevent workers from being exposed to pesticides in a treated area.

Restricted-Entry Interval

The employer is responsible for keeping workers out of the treated area by following the restricted-entry interval documented on the pesticide label. Employers may notify workers in different ways, including by:

- ◊ Oral notification
- ◊ Posting warning signs
- ◊ Double notification

Note: The WPS also requires employers to monitor and assist workers in avoiding heat stress.

Figure 1.2.4.a. Restricted-entry interval signs must be posted to alert workers and handlers of pesticide applications. Pesticide label information may show an REI of 4 to 48 hours. No one should enter those areas until warnings are removed. Illustration by Andy Mylan

REI = Restricted-Entry Interval

Safety Activities

1. Ask your employer or local agricultural chemical sales representative to show you a pesticide label from the pesticide files. Use the label and/or SDS to answer these questions. SDS information can also be found on the Internet.
    a. What are the health hazards of the product to humans?
    b. What personal protective equipment is required to use the product?
    c. What are the spill control procedures to use for the product?
    d. What is the REI of the product?

2. Use the Internet to search for specific WPS regulations for farm, greenhouse, nursery, and forest pesticide applications.
3. Review the Hazardous Occupations Order in Agriculture for the exact wording of the rule that prohibits workers younger than age 18 from working with pesticides.

Resources

U.S. Department of Agriculture website, **www.usda.gov**.

U.S. Environmental Protection Agency "Pesticide Worker Safety: Agricultural Worker Protection Standard (WPS)" website, **www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps**.

State Vehicle Codes

Learning Goal

◊ Understand the state regulations that affect the implements of husbandry used on public roads

Related Task Sheets

◊ 1.2: Safety and Health Regulations
◊ 4.14: Operating the Tractor on Public Roads

Figure 1.2.5.a. Know the rules for taking a farm tractor and implement onto public roadways. Credit: Penn State Extension Ag Safety Team

Introduction

Each state's governing authority has passed laws regarding motor vehicle use in their state. Tractors and machinery are sometimes used on public roads to transport equipment and products. Special rules in the motor vehicle codes apply to ensure agricultural producers use the roads safely.

This task sheet discusses state vehicle codes for Pennsylvania. Inclusion of every state's interpretation or language regarding farm implements is not possible.

See the Safety Activity section for an assignment for your location.

Example Vehicle Code

Our example is the Pennsylvania Vehicle Code (PA Code), which includes several provisions that apply to the movement of agricultural equipment on public roadways. Definitions and requirements should be noted when examining your local vehicle code. For example, the definitions for implements of husbandry and highway are of concern to agricultural employers and youth tractor operators. References concerning licensing and exemptions from licensing are also noteworthy.

Implement of Husbandry Defined

"Implement of husbandry" is defined as "farm equipment designed or adapted and determined by the Department of Transportation to be used for agriculture production, harvesting or transportation of agricultural products or supplies and only infrequently operated or moved upon highways."

Highway Defined

A second definition of importance is that of "highway." Highways include "the entire width

between the boundary lines of every highway publicly maintained when any part is open to the use of the public for purposes of vehicle travel." Any road, including shoulders and berms, open to the public is referred to as a highway.

Licenses Required

Section 1501 of the PA Code has a general statement that requires all persons who operate motor vehicles on a highway to have a license unless specifically exempted elsewhere in the code. Special code sections may explain exemptions and restrictions to the licensing requirements. For instance, PA Code Section 1502 Part (5) says: "Persons 14 or 15 years of age are restricted to the operation of implements of husbandry on one and two-lane highway which bisect or immediately adjoin the premises upon which such person resides." In other words, **14- and 15-year-old youths can operate farm tractors only on public roadways that bisect or adjoin their place of residence**. Many farm employers, parents, and youth are probably unaware of this restriction.

What should you consider to legally operate a tractor on the road?

Other Rules of the Road

Regulations, and the exemptions to those regulations, standardize the "rules of the road." Vehicle codes may exempt farm equipment from brake systems, bumpers, mirrors, horns, lights, and inspection.

Wide Loads and Passing

In the example provided, Pennsylvania law states that a wide load (wider than a single lane) should be pulled entirely off the road at the first reasonable and safe location to allow following motorists to pass. Be sure to use the correct signals to show your intended actions. Never wave the traffic around you—it makes you responsible for what the other driver does.

Load Listing

Towed loads that deflect from the path of the drawing vehicle create a hazard. Pennsylvania law covers pulled loads that weave back and forth. Towed loads may have no more than 6 inches of deflection from the path of the drawing vehicle's wheels.

Safety Chains

Pennsylvania law does not provide an exemption to agriculture regarding the use of safety chains. Use safety chains to secure the load. See Task Sheet 4.14 for more information.

Insurance

Some codes may require special insurance coverage for agricultural equipment used on roadways. In some cases, common courtesy must also be used. Promote agriculture's positive image by sharing the road safely and responsibly.

Figure 1.2.5.b. Promote the positive image of agriculture. Share the road safely and responsibly by obeying your state's vehicle code. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Go to your state government website and search for the vehicle code.
2. Using any Internet search engine, type in "implement of husbandry" and "public roadways" to search for your state's vehicle code or information regarding this subject.
3. If you cannot find the information in Activity 1 above, contact your local state representative and ask for a copy of the state motor vehicle code. This is a long document, so use the table of contents and the index to locate the rules and exemptions your state makes for agriculturists using the public roadways. The local public library may also be a good source for this document.
4. Give a poster presentation to local farm groups to review the requirements of your state's vehicle code.
5. See Figure 1.2.5.a. Are there any rules for taking this farm tractor and mower-conditioner onto public roadways? Check the vehicle code for your state to find out. Write a one-page report for your club, class, or mentor about your findings.

Environmental Regulations

Learning Goals

- Understand that farm equipment operators are responsible for environmental protection
- Understand what to do if a spill poses a hazard to the environment

Related Task Sheets

- 1.2.4: Agricultural Worker Protection Standard
- 1.2.5: State Vehicle Codes
- 1.4: State Agricultural Safety and Health Resources
- 1.5: National Agricultural Safety and Health Resources

Introduction

Agricultural production activities generate a variety of by-products that can enter the environment. Control and management of these by-products is important to prevent degradation of water, soil, and air. When natural resources become unfit for agricultural production, it impacts farmers' and ranchers' production potential.

This task sheet will discuss the environmental regulations that farm equipment operators and workers must know.

Environmental Rules

Environmental laws are enforced by the Environmental Protection Agency (EPA). These laws include provisions for clean air, clean water, safe pesticide use, and safe drinking water standards.

These federal laws also have state and local counterparts and enforcement officials. States have Department of Environmental Resources (DER), and local governments also have ordinances. Farmers and farm employees should have an understanding of all the regulations that are designed to protect our natural resources.

EPA = Environmental Protection Agency

What Typical Laws Cover

Typically, farmers are held to high standards in protecting the environment. What do you know about the following areas?

- Water pollution
- Air pollution
- Drinking water standards
- Pesticide rules and regulations
- Shifting load violations
- Used tire disposal
- Trash burning hours and rules
- Battery disposal
- Oil and fuel spills
- Used oil disposal
- Sinkhole protection
- Manure spreading

Each of these subjects will have a federal, state, or local ordinance that affects each citizen. Penalties for violating the law can include fines for breaking the law and payment for property damages.

If you think a task you are assigned can pollute the air, water, or soil, ask your employer if you are causing a legal problem for them.

Figure 1.3.a. Manure spills on highways must be kept from leaking into streams (i.e., controlled and contained) and cleaned up. The nearest Department of Environmental Resources must be notified. Your best action is to notify local police and fire companies to direct and control traffic during the cleanup. Illustration by Andy Mylin

Manure Handling and Spills

Incorrectly applying manure and pesticide can pollute water. This section will discuss manure loading, transporting, and application.

Roadway spills require:

- ◊ Control
- ◊ Containment
- ◊ Cleanup

Manure Handling

Manure handling can take many forms. Solid, semi-solid, and liquid manure handling involve several types of equipment. Front-end loaders or gravity flow storages may be used. Gravity-filled liquid manure tanks are more likely to pose environmental spill risks since they may store several hundred gallons of manure. A stuck manure pit valve can cause immense problems due to spills.

Manure Transportation/Spills

Hauling manure poses safety concerns on the highway since manure can take different forms and be difficult to handle. Shifting load violations carry penalties under law. For example, Pennsylvania regulations require farmers to use methods, equipment, and facilities in ways that do not pose health or safety risks to the environment.

Should a spill occur, the operator must take immediate steps to control, contain, and clean it up. In addition, your local environmental agency must be notified. Penalties may be assessed. Notifying local police and fire officials is important if traffic is to be controlled and directed.

Manure Application

Manure application on farm fields should be done with water quality and nutrient management regulations in mind. Here are a few points to consider:

- ◊ Manure spread on frozen soil may eventually finds its way into waterways due to runoff.
- ◊ Manure spread close to streams, ponds, wells, and springs contaminates these water resources.
- ◊ Manure contains nutrients such as nitrogen and phosphorus that feed plants but in excess can pollute underground water and streams.

Farms should have a plan in place to deal with manure leaks or spills. The plan should be posted and known by employees. Adequate equipment and supplies should be available, and phone numbers of local police and fire officials should also be available.

Pesticides

Handling and application of pesticides in any manner by workers younger than age 18 who are not immediate family members of the owners of the agricultural establishment is restricted by the Worker Protection Standard (see Task Sheet 1.2.4).

Burning Trash

Youth farm workers may be assigned the task of burning trash from around the farm. While such a job seems easy, there may be some hidden environmental risks involved. Toxic materials may pose air pollution threats. Local burning laws may be violated.

Toxic Materials

Pesticide containers, chemical cleaners, and tires have found their way to burning areas. The toxic fumes released from these materials may make you sick or cause severe health problems. Ask your employer if a hazard is associated with what they have assigned you to burn.

Burning Ordinances

Local government laws may limit burning to certain items on certain days and at certain times of the day. Ask your employer about these local laws.

Fuel, Oil, Lubrication —Spills and Disposal

Laws exist to protect the environment, but farmers should also want to prevent their own properties from becoming polluted. Waste from equipment service and maintenance often becomes a source of pollution. Sources of pollution from farm shop machinery and buildings include:

- ◊ Used oil
- ◊ Oil filters
- ◊ Antifreeze
- ◊ Paint and solvents
- ◊ Air conditioner refrigerant
- ◊ Spilled or dumped fuel
- ◊ Fuel, oil, and lubricant containers

Ask your employer for a copy of the Safety Data Sheets (SDS) so you can review proper handling and cleanup.

Material spills sometimes happen. If fuel, oil, lubricants, or coolants are spilled, check the container label or SDS for the method of cleanup. Major spills require contacting local and state authorities.

Disposal information for hazardous materials can also be found on labels and SDS. Community collection points can be used to dispose of many materials. Contact your local recycling coordinator or Cooperative Extension service for information on local recycling efforts.

Tire, Battery, and Garbage Disposal

Some materials are more difficult or costly to discard. Tires laying around become water-filled breeding grounds for mosquitoes. Batteries pile up in the corner. Some garbage should not be burned. What should be done?

Tire dealers and battery suppliers must accept these items from you. A disposal fee may be charged. Alternative uses for tires may be found as well.

Garbage that cannot be burned should be disposed of properly. On-farm burial or use of landfills is possible. Read the labels on all materials to know the proper disposal methods.

Contact EPA at 1-800-424-9346 to learn more about the disposal of hazardous materials.

Figure 1.3.b. Pesticide containers will specify the method of disposal on the label. Youths younger than age 18 should not handle or apply pesticides. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Write a report concerning the problems you can identify as you read the introduction to this task sheet. In the report, name the problem and explain why there is a problem.
2. Make as many words (three or more letters) as you can from the title "Environmental Protection Agency." Score one point for each word you find. To challenge yourself further, list only words that deal with clean air, clean water, safe pesticide use, and soil contamination.
3. Contact local municipal authorities (township supervisors) to request a copy of local burning ordinances.
4. Ask a state highway officer to tell you about farm machinery accidents involving manure and pesticide spills. Also ask them about shifting load violation penalties.
5. Write a short essay about how to control, contain, and clean up a manure spill.
6. Research the subject of nutrient management to determine how much nitrogen, phosphorus, and potassium is needed by corn, alfalfa, and soybeans. Explain how nitrogen and phosphorus from manure can become a pollutant in our water supplies.
7. What problem does excess nitrogen and phosphorus cause in our waterways?

Resources

Pennsylvania Department of Environmental Protection website, **www.dep.state.pa.us**. (Search the Internet for your state's Department of Environmental Protection website.)

Pennsylvania Department of Transportation website, **www.dot.state.pa.us**. (Search the Internet for your state's Department of Transportation website.)

U.S. Environmental Protection Agency website, **www.epa.gov**.

HOSTA Task Sheet 1.4

State Agricultural Safety and Health Resources

Learning Goal

◊ Become familiar with your state's ag safety professionals as a source of safety information

Related Task Sheet

◊ 1.5: National Agricultural Safety and Health Resources

Introduction

Do you know where to find information about agricultural safety in your state? Safety professionals offer a wide variety of information, materials, demonstrations, and programs. "Safety" experts are available throughout the United States.

This section discusses state agricultural safety resources that can help youth learn more about working safely and successfully on the farm or ranch. Learn what your state resources are and how to contact them.

State-Level Resources

Some state safety resource programs employ specialists who provide safety training or demonstrations or guidance to other resources to answer safety questions. Here are safety resources you may have in your state:

◊ College of agriculture specialists in agricultural safety and health
◊ Cooperative Extension service (offices in each county)
◊ Agriculture and extension education program specialists in 4-H and FFA at the state level (contact your state 4-H office and Department of Education)
◊ State Farm Bureau safety leaders
◊ Colleges of health/nursing and university medical centers/hospitals
◊ Veterinary medicine colleges
◊ State Departments of Health or Rural Health specialists
◊ State fire instructors

Your state has ag safety experts. Learn who these experts are.

How can you contact these resources?

While a quick Internet search may provide information, it could take time to sort. Consider reaching out to your state's land-grant university. A goal of your state's land-grant university is to provide agricultural training as a means of improving agriculture. Agricultural safety is one area of this training For instance, in Pennsylvania, Penn State started as the "Farmers' High School."

Where is your land-grant university located?

Use the Internet to find the land-grant university and Cooperative Extension service in your state. Search for "agricultural safety" resources. Contact information such as email or telephone numbers will usually be provided. Sending a message is a great way to start a conversation about agricultural safety and health. Some may have a social media presence such as Facebook or Twitter.

Figure 1.4.a. The Department of Agricultural and Biological Engineering at Penn State is just one of many such departments in each state that offer a source of agricultural safety information. Take time to learn about the land-grant university in your state. Image courtesy of Penn State

Community-Level Resources

Local resources are also available to provide safety information.

Public Sources

Public organizations are government related and taxpayer supported. Information may be free or inexpensive. Some of these resources include:

- State Police or Highway Patrol (traffic laws and road hazards)
- County Coroner (investigations into farm-related fatalities)
- Regional Departments of Agriculture (statewide and county data on the scope of agriculture, agricultural fairs and expositions, and grants for farm safety projects)
- Local Departments of Health (safety information)

Private Sources

Private sources are businesses that serve the agricultural industry. Several examples include:

- Electrical service suppliers and vendors (safety programs)
- Machinery and equipment dealers (films on safety and equipment operation training materials)
- Veterinarians (animal health and handling safety)
- Local doctors and nurses (emergency medical help for farm accident victims and injury prevention ideas)
- Ag pesticide representatives (pesticide use and safety training seminars)
- Volunteer fire departments (fire prevention and agricultural rescue programs)
- American Red Cross chapters (CPR and First Aid training)
- Emergency medical services (ambulance services and First Aid classes)
- Safety consultants (charge a fee to assist in safe work practices)
- Insurance companies (brochures on safety issues and presentations about safety)

Safety Activities

1. Use the Internet to visit the website of your land-grant university to learn more about farm safety.
2. Use the Internet to visit the website of your state's Department of Agriculture to learn more about farm safety programs. Do they have a grant program for youth organizations to conduct safety activities? Do they have a Safety Quiz Bowl competition? Learn how you can participate.

Resources

Cooperative Extension county office; for example, Penn State Extension, **extension.psu.edu/counties**.

National 4-H website, **www.4-H.org**.

National Future Farmers of America website, **www.ffa.org**.

State Department of Agriculture; in Pennsylvania, **www.agriculture.pa.gov**.

State land-grant university and/or college of agriculture; for example, the Penn State College of Agricultural Sciences, **agsci.psu.edu**.

National Agricultural Safety and Health Resources

Learning Goal

- Become aware of the many national agricultural organizations available as sources of safety information

Related Task Sheets

- 1.2: Safety and Health Regulations
- 1.2.1: Hazardous Occupations Order in Agriculture
- 1.2.2: Occupational Safety and Health Act
- 1.4: State Agricultural Safety and Health Resources

Introduction

Agricultural safety issues do not rest in the hands of a few concerned people. Many groups at the national level understand the hazards of the agricultural industry. They are dedicated to protecting a vital part of the farm and ranch workforce—young people.

This section discusses national sources of farm safety information. Contact them to learn how you can increase your safety knowledge.

Ag safety info can come from many national sources.

Public/Governmental Agencies

Federal and state government departments are considered public agencies because they exist due to public funding through tax dollars. Many of these can be contacted through the Internet.

AgrAbility

Providing educational, technical assistance, and financial information is the main function of AgrAbility programs in several states. AgrAbility also works with nonprofit disability service organizations (e.g., Easterseals) to provide services to farmers with disabilities. USDA NIFA sponsors this program.

Environmental Protection Agency (EPA)

EPA is a federal regulatory agency assigned the responsibility of protecting the air, water, and natural resources of the United States. Pesticide laws and air and water pollution regulations affect our farms. See **www.epa.gov** to learn more.

National Institute for Occupational Safety and Health (NIOSH)

This branch of the Centers for Disease Control and Prevention (CDC) is responsible for conducting research and making recommendations for the prevention of

work-related injury and illness, including in agriculture. Check out **www.cdc.gov/NIOSH**.

Agriculture Safety and Health (ASH) Centers

Supported by NIOSH, ASH Centers provide safety education programs specific to their geographic location. Go to **www.cdc.gov/niosh** to locate each center.

National Children's Center for Rural and Agricultural Health and Safety

Sponsored by NIOSH, this center promotes farm safety for children. One program that creates safe play areas on farms draws attention to helping small children grow up safely on farms. Explore their resources at **www.marshfieldclinic.org**.

Occupational Safety and Health Administration (OSHA)

This is regulatory agency for safe workplaces. See Task Sheet 1.2.2 and **www.osha.gov** to learn more about OSHA regulations related to agriculture.

Vocational Rehabilitation

One of these offices can be found in each state as part of its Bureau of Labor and Industry (Pennsylvania designation). This agency assists citizens with disabilities to gain economic independence. Specialized services are available from Vocational Rehabilitation offices. Financial aid may be available to assist a farmer with a disability.

U.S. Consumer Product Safety Commission (CPSC)

This federal regulatory agency works with industry to develop and implement standards for safety in consumer products. The CPSC can recall unsafe products. Visit **www.cpsc.gov**.

U.S. Department of Agriculture (USDA)

USDA serves rural America and the agricultural community through education, research, and regulation of food production and safety, conservation, and worldwide market development. Go to **www.usda.gov**.

Cooperative Extension Service

The USDA Cooperative Extension service brings safety information to the state and local levels through county offices.

U.S. Department of Labor (DOL)

This is the labor regulatory agency of the U.S. government. Child labor laws such as the Hazardous Occupation Order in Agriculture (see Task Sheet 1.2.1) are enforced through this agency. Visit **www.dol.gov** to learn more.

Corporate Sources

Many corporate groups are sources of information about agricultural safety. A few are listed below; try finding them on the Internet. You may discover more as you develop your safety awareness.

Vendors:

- ◊ Gempler's Inc.
- ◊ NASCO

Equipment manufacturers:

- ◊ Deere and Company Case IH
- ◊ Dow Monsanto DuPont Novartis
- ◊ Kubota Chemical Company
- ◊ New Holland AGCO

Note: This listing is for example only and does not represent endorsement of any specific vendor or manufacturer.

Nonprofit Sources

Some organizations or associations exist as nonprofit groups. They work toward a common good for their industry or interests.

American Society of Agricultural and Biological Engineers (ASABE)

This professional and technical organization is dedicated to the advancement of engineering in agriculture, food, and biological systems. Find them at **www.asabe.org**.

Association of Equipment Manufacturers (AEM) and Farm Equipment Manufacturers Association (FEMA)

These two associations represent large and small companies. AEM is a trade and development resource, while FEMA represents the common interests of hundreds of smaller companies. Find them at **www.aem.org** and **www.farmequip.org**.

National Agriculture Safety Database (NASD)

This is the national central storehouse of agricultural health, safety, and injury prevention materials. Agricultural statistics on injury and death can be found in this database. Initial funding for this effort came from NIOSH and USDA. Currently, funding is mostly from CS-CASH with supplemental funding from SCAHIP and HICAHS. See **https://nasdonline.org** for more information.

National Lightning Safety Institute (NLSI) and United Lightning Protection Association (ULPA)

These are two similar associations. NLSI promotes lightning safety for people and structures, while ULPA promotes high-quality, safe design and installation of lightning protection systems. See **www.lightningsafety.com** and **www.ulpa.org**.

National Safety Council (NSC)

This is a federally chartered, nonprofit, nongovernmental source of safety and health information. Education in safety, safety resources, and farm safety statistics are available from this group. Check out **www.nsc.org**.

SAY Project

The project provides a clearinghouse of curriculum resources that align agricultural safety and health curriculum and educational resources to Agriculture, Food, and Natural Resources (AFNR) Career Cluster Content Standards used by agricultural educators.

Youth Organizations

The following youth organizations also serve agriculture. What safety programs do they offer? Use the Internet or contact local 4-H leaders and agriculture teachers to find out more.

- National 4-H Organization
- National Center for Farmworker Health
- National Future Farmers of America
- SAFE KIDS Worldwide

Careers are available in the field of agricultural safety. Would you consider one?

Safety Activities

1. Organize a list of Internet websites that discuss agricultural safety. (Hint: Try the land-grant university in your state first.) Then use the Internet to look for those organizations and resources discussed in this task sheet. You can expect to find dozens of sources. You can also search for federal and state government agencies, talk to local secondary agricultural education instructors, or contact safety associations and corporations.
2. Many government agencies can provide information about farm safety. Use the Internet to research what the Consumer Product Safety Commission does.
3. Use the Agricultural Youth Work Guidelines (cultivatesafety.org/work) to find out more about this resource. Find out how to produce a safety calendar. The website describes how to customize a safety calendar for your family or group. Perhaps you could make a farm safety calendar for your home, club, or school.
4. Call the Cooperative Extension office in your county and ask to have safety publications mailed to you.
5. Use a national chain store catalog (e.g., Gempler's) to make a list of their available safety materials. List the price tag as well. Safety is a large and important business.
6. Call your local volunteer fire department to inquire as to whether they have a junior member eligibility. Perhaps you could join the group to learn more about fire safety and rescue techniques.
7. Volunteer at local Red Cross and/or Easterseals chapter to help others in your community.

2

Section Two
Safety Basics

Injuries Involving Youth

Learning Goal

◊ Learn about the numbers and types of injuries associated with youth working in agriculture

Related Task Sheets

◊ 1.2: Safety and Health Regulations
◊ 1.2.1: Hazardous Occupations Order in Agriculture
◊ 2.4: Age-Appropriate Tasks

Introduction

"I'm always careful! I'll never suffer a work injury!" You may say this to yourself as you begin to read this task sheet. But this same thinking is what injures and kills hundreds of people on farms and ranches.

This task sheet looks at the numbers of fatalities and injuries that have caused great concern in farming and ranching.

If you work in production agriculture, don't become part of the injury statistics.

The Situation

The fatal work injury rate per 100,000 workers regularly ranks agriculture among the most hazardous industries in the United States. The agriculture industry often records numerous injuries and fatalities to youth. Unlike agriculture, other industries, like mining and construction, have regulations that do not allow youth younger than 16 to work in hazardous occupations.

Youth Farm Injury Statistics

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.

Special studies relying on voluntary cooperation by farmers are done to find out about injuries to youth in agriculture. As a result, injury statistics in agriculture are often underestimated due to the lack of a standardized reporting system. The facts below are national data.

Fatality Facts

◊ 2018 Census of Fatal Occupational Injuries Data indicated approximately 574 fatalities associated with working in the agriculture, forestry, fishing, and hunting industries.
◊ The 2018 fatal work injury rate was 22.8 per 100,000 full-time equivalent workers.
◊ Statistical estimations indicate that nationally every three days a child dies from an agriculture-related incident.

Injury Facts

- An estimated 11,942 youth were injured on U.S. farms in 2014.
- An estimated 5,376 youth between the ages of 10 and 15 were injured in 2014.
- Statistical estimations indicate that nationally every day a total of 33 children are injured in an agricultural-related incident.

State Data

Contact the safety specialist at your land-grant university to learn the farm injury statistics for your state.

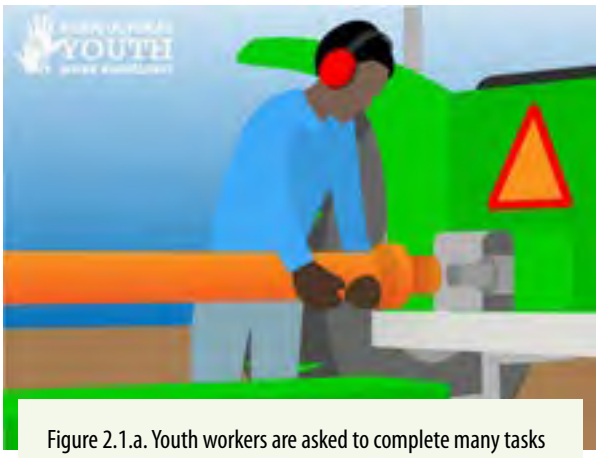


Figure 2.1.a. Youth workers are asked to complete many tasks that may present several hazards. Credit: National Children's Center for Rural and Agricultural Health and Safety

How Can I Use This Information?

Farm family workers, hired workers, children of seasonal and migrant workers, and farm visitors can all encounter a wide range of hazards in agriculture. Machinery, livestock, farm storage structures, and farm ponds all present unique safety challenges. Follow these safety suggestions to avoid becoming a farm injury or fatality statistic:

1. Identify agricultural hazards in the work area to which you are assigned.
2. Develop a plan to deal with the hazards you identified.
3. Use safety practices all the time.
4. Think about the consequences of your 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 your safety on the job.

Being safe is largely a matter of choice. What are the consequences of unsafe actions?

Figure 2.1.b Agriculture presents unique safety challenges. You are challenged to work safely in many conditions. Not all work is done with tractors and machinery. Credit: National Children's Center for Rural and Agricultural Health and Safety

Safety Activities

1. Review what you have read by completing this quiz:
   a. True or false? Most fatal injuries to farm youth occur to females.
   b. What are the three leading causes of injuries?
   c. True or false? Most farm injuries involve working with fruit trees.
   d. What percentage of farm fatalities involved machinery?

2. Go to **www.bls.gov** to locate information comparing the work fatality of agriculture with other industries. Use a computer to make a chart or graph to summarize the data. If you do not have access to a computer, make a full-size poster of the information to share with your group.

References

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Risk Perception

Learning Goal

◊ Understand how we think about risk

Related Task Sheets

◊ 1.1: The Work Environment
◊ 2.1: Injuries Involving Youth
◊ 2.3: Reaction Time
◊ 2.4: Age-Appropriate Tasks

Introduction

Why do people take risks? Has past experience taught you that taking a risk is acceptable? Have you also learned that risk-taking increases your chances of injury?

Risk can be measured. The odds of injury and a prediction of the consequences of risk-taking have been studied by safety specialists. A person's perception (how we judge risk) about work risks comes from personal judgments made about a work situation.

This task sheet discusses risk-taking and the perceptions people have about risks. Risk-taking behavior is a topic that all workers must understand.

The Nature of Risk

Risk can be defined as "the chance you take of becoming injured by a hazard." No one can deny that all people take risks. We risk our lives and health each day. Some risks are minor—we don't expect that everyone will smash their finger in the car door. Other risks are major—driving too fast increases the risk of a crash and possible injury. We are exposed to risks every day.

Assessing your risk of injury starts with probability (odds or chances). What are the odds or chances that we can be injured by a specific hazard? Most people do not judge the probability of risk very well. The odds of risk can be placed in categories, which are described later in the task sheet.

Risk assessment also includes how seriously you can be injured by a hazard. Risks can be great (death) to negligible (splinter). The severity of the consequences of risk are discussed later in this task sheet.

Risk perception is an important concept in safe work activity. Human perceptions of risk are not very accurate. Our judgments about risks are based on several things. One important factor is how familiar we are with a hazard. If we think we know a lot about a hazard because we are often exposed to the hazard, we often underestimate the degree of risk.

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

A third factor is how much attention a hazard brings if someone gets hurt. We tend to think that there is a great risk in flying in an airplane (kills many people at one point in time and gets more attention). We underestimate the hazard of driving a car. An automobile crash may kill one or two people at a time but only receive local attention.

A person must understand risk, the probability of injury, and the severity of the consequences that can result.

Figure 2.2.a. We view some jobs as more hazardous than others. When we understand that the consequences of taking a risk can lead to injury or death, we improve our safe work habits greatly. National Children's Center for Rural and Agricultural Health and Safety

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

Probability

Work, and all other activity, involves risks. Some risks are very small. Other risks are great. What are the odds (or chances) that you will be injured while engaged in an activity?

The subject of probability is a study of the odds or chances of a single event actually occurring out of the possible times it could occur. For example, if you roll a single die (dice), the odds of rolling a one is one out of six.

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

- **Frequent exposure:** Probability is likely/possible on a daily basis (for example, daily use of a PTO-powered implement is a frequent exposure to this hazard).
- **Probable exposure:** Probability is likely/possible on a weekly or monthly basis (for example, weekly or monthly inspections of the silo unloader give a probable exposure to the hazards of a fall).
- **Occasional exposure:** Probability is likely/possible over a year or many-year time period (for example, a yearly skiing trip provides the occasional exposure to the risk of a ski injury).
- **Remote exposure:** Probability is not likely, but it is possible over many years, even a lifetime (for example, the owner of a barn rarely paints the barn's roof, so the exposure to a fall injury is considered a remote probability; however, a barn roof painter would be frequently exposed to the same risk).
- **Improbable exposure:** Probability is unlikely but still possible (for example, nuclear power radiation poses an improbable exposure).

From these probability ratings we can see that the less exposure to risk we have, the less likely our odds of injury or death.

What are the odds you will be injured while working?

Figure 2.2.b. What are the odds that you will be hit by lightning? Using the rating system below, a measure of the probability of risk would be determined by how often you were exposed to the dangers of a lightning storm. Since most people take shelter during a lightning storm, the probability is remote.

Consequences of Risk Exposure

Just as the probability of risk exposure can be assigned a frequency category, the consequence of risk exposure can also be assigned a consequence category. The consequences of risk exposure by severity of outcome can be categorized as follows:

- **Catastrophic severity:** Injury or death is imminent (near), and there is potential for widespread loss (for example, death from operating a non-ROPS tractor that rolls over poses a great risk).
- **Critical severity:** Severe or permanent injury, long-term illness, and temporary property loss are possible (for example, trying to unplug a corn picker that is running can lead to entanglement and potential loss of an arm or leg).
- **Marginal severity:** This refers to less serious risk exposure with shorter-term losses (for example, falling from a horse and breaking an arm is less severe than having an arm amputated due to a PTO entanglement).
- **Negligible severity:** The risk exposure event results in the need for first aid or property losses that are easily repaired (for 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 like an equation with a resulting answer (what to do to reduce risk). See if you can use the Risk Matrix Table below to answer the following question: "What is the risk of climbing over a turning, unguarded PTO shaft every day?" Can you rank all of your work activities with this matrix?

Select a work activity that you perform and rate the severity of the risk.

Reducing Risks

People take risks every day. Some risks are seen as acceptable because of past experiences, our own notions and overconfidence of the risk situation, and our willingness to accept the risk. The following points are important to consider in reducing the risk to which a young worker is exposed:

1. Recognize your own traits that increase risk. Are you impatient about getting work done?
2. Recognize when you need more training to do a job. Risk-taking behavior can be reduced by knowing the hazards.
3. Remove hazards from the workplace. The fewer hazards that exist in the work zone, the less risk of danger that exists.
4. Use safe technology correctly. Modern farm machines are engineered to reduce risks to the operator. The operator must use this technology safely.

Figure 2.2.c. Modern farm equipment has many more safety technologies than older machinery. Future advancements may include sensors that detect when a person enters a hazardous area, causing the tractor and machine to shut down to keep the operator or bystander from harm. Credit: Michael Houtz, Penn State Extension

Risk can be equated with expected damage or injury consequences.

Applying a Risk Matrix Table to Reduce Risk Probability

The Risk Matrix Table provides a means of evaluating a risk and what to do to reduce the consequences of the risk exposure.

Frequency	Catastrophic Severity (1)	Critical Severity (2)	Marginal Severity (3)	Negligible Severity (4)
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

Safety Activities

1. Write a short essay about a time or event in which you took a risk.
2. From your essay, what were your feelings after you had time to look back on the risk you took? Write a few notes about your feelings.
3. Make a list of risk-taking situations that you have experienced. Place these examples into the appropriate risk category.
4. What do you recognize about yourself that might indicate that you are a risk-taker?
5. Take a safety tour of a farm area. First list the hazards and then list the chores that you find risky.

References

Murphy, D. J. *Safety and Health for Production Agriculture*. St. Joseph, MI: American Society of Agricultural Engineers, 1992.

Reaction Time

Learning Goals

- ◊ Recognize that personal reaction time is slower than the speed of a machine
- ◊ Work safely by paying attention to safe procedures and sound practices based on knowing the limitations of human reaction time

Related Task Sheets

- ◊ 2.4: Age-Appropriate Tasks
- ◊ 3.1: Mechanical Hazards
- ◊ 4.3: NAGCAT Tractor Operation Chart
- ◊ 5.4.1: Using Power Take-Off (PTO) Implements

Introduction

How fast can you react? Are you faster than a rotating PTO shaft? Reaction time is defined as the time it takes for a person to react to an event or an emergency. Emergencies occur without warning. Our past experience combined with our reaction time determines how well we respond to an emergency event.

This task sheet discusses reaction time as it relates to you and the speed of the machines with which you work. Machines are much faster than a human's reaction time. No one is faster than a speeding machine.

Reactions Are More Complex Than You Think

Reacting to a given situation or emergency involves a complex sequence of events. Consider when an animal jumps in front of your car as you travel down a road. What happens next?

- ◊ Your eye gathers the information "animal in road" and sends a message to your brain.
- ◊ Your brain receives the information, processes the information, and sends a response to your extremities (arms and legs).
- ◊ Your leg muscles must move your foot from the gas pedal to the brake pedal and begin to push the pedal.
- ◊ The vehicle continues to move as you respond until the car finally stops just before you hit the animal—or after you have demolished your car.

Here are a few more examples of hazardous situations:

- ◊ Touching a hot stove
- ◊ Recognizing that your shirt sleeve is being caught on the drill press chuck
- ◊ Realizing that your shoe string is dangling over the PTO shaft that you should not be stepping across
- ◊ Pulling a tractor and load onto the highway and seeing a fast-moving vehicle coming your way
- ◊ Trying to unplug a corn picker and being pulled into the gathering chains

Situations like these can occur anytime and anywhere. Remember, events like these do

not give you time to think about what you will do. You react to a situation as it occurs with no warning or time to plan or prepare for action.

Many factors affect your reaction time. Read further to find out why you cannot beat a machine in an emergency. Your life may depend on this information.

Figure 2.3.a. Never step across a turning PTO shaft. Loose clothing can be pulled into the shaft before you are able to react. Illustration by Jeff Mathison

People are not the "super heroes" of television fame. No one is faster than a speeding machine.

Factors That Affect Reaction Time

- ◊ Experience
- ◊ Age
- ◊ Fitness
- ◊ Fatigue
- ◊ Illness
- ◊ Preoccupation
- ◊ Distraction
- ◊ Mood
- ◊ Drugs/medication
- ◊ Alcohol and tobacco
- ◊ Machine vibrations
- ◊ Poor vision
- ◊ Poor hearing

Some Things to Think About

- ◊ Experienced operators have gained knowledge of potential hazards. Beginning operators may not know when danger exists.
- ◊ Healthy, well-rested operators think through hazardous situations more clearly than fatigued workers.
- ◊ Distracted or daydreaming operators are less cautious than focused workers.
- ◊ Frustrated workers tend to make bad decisions.
- ◊ Medications, as well as drugs, alcohol, and tobacco, can slow your reaction time.
- ◊ Machine vibrations have been shown to fatigue operators and reduce reaction time.
- ◊ Poor vision and hearing can lead to poor reaction time.

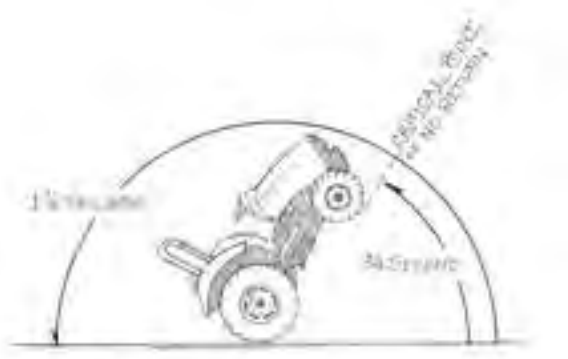


Figure 2.3.b. A tractor can upset in ¾ second. Our reaction time will not prevent the injury and damage that can occur. Can you tell why the tractor would rear up as shown in this picture? Illustration by Jeff Mathison

If your reaction time is ¾ second, a tractor tipping backward can reach the point of no return before you can react.

Rotating Parts Are Everywhere

Working around or near shop equipment, machinery, or tractors—as opposed to working in an office—exposes you to more hazards.

Rotating parts such as the following are everywhere:

- ◊ Grinding wheels
- ◊ Drill presses
- ◊ Chainsaws
- ◊ Lawn mowers
- ◊ Augers
- ◊ Belts and pulleys
- ◊ Chains and sprockets
- ◊ Gears
- ◊ Power take-off (PTO) shafts

All exposed rotating parts of farm tools and equipment operate faster than you can pull away should clothing become entangled.

PTOs and Reaction Time

Now is a good time to ask, "Are you faster than a speeding machine? Can you react faster than the machine and avoid injury or death?"

We have all been warned not to step over a turning PTO shaft, but PTO entanglements are still happening. A simple arithmetic problem can be used to explain what can happen should your pant leg be caught on an unguarded rotating shaft. The unguarded PTO shaft is turning at 540 RPM (rotations per minute). Instead of walking around the tractor or piece of equipment, you decide to step over it to save a few steps and seconds. You feel a tug on your pants leg and begin to pull away.

With a reaction time of ¾ second (0.75), how many turns of the shaft will be tugging at your pants before you begin to pull away (if you can at all)? First, convert 540 RPM to revolutions per second (RPS) by dividing 540 by 60 seconds.

$$540 \div 60 = 9 \text{ RPS}$$

Second, multiply 9 RPS by your reaction time to get the revolutions of the PTO shaft before you begin to pull away.

$9 \times ¾ = 27 \div 4 = 6.75$ or $9 \times 0.75 = 6.75$ revolutions before you react or begin to pull away.

Avoid Hazards from Rotating Parts

To avoid becoming entangled in rotating parts:

1. Keep guards in place on rotating shafts and parts.
2. Stop the engine before dismounting the tractor.
3. Dress safely to avoid entanglements.
4. Before you take a chance, think, "Is saving a few seconds or steps worth risking my life?"

Figure 2.3.c. Mobile devices and other digital distractions can reduce your ability to monitor the machine. Be sure to stay focused on the task at hand. Texting or posting on social media while working can create a risk for injury. Credit: Penn State Extension Ag Safety Team

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

Figure 2.3.d. Be sure PTO shaft guards and stub shields are in place. Credit: Penn State Extension Ag Safety Team (shaft guards) and Jeff Mathison (stub shields)

Safety Activities

1. If you are involved in an agricultural education mechanics program, ask the instructor if you can conduct a survey of electric motors on machines and small appliances (drills, portable saws, etc.) to chart the speed in RPM of those motors. The speed of the motor in RPM is found on the motor nameplate. Make a table of the information as follows:

Motor/Machine	Speed of Motor
Table saw	1,740 RPM

2. Conduct Activity 1 in the farm shop or your home with any electrical appliance on which you can view the electric motor information on the nameplate.
3. Using a stopwatch, 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

4. 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 RPS.

Hint 2: There are 60 seconds in a minute.

Hint 3: Multiply RPS (Hint 1) by your reaction time in Activity 1 or 2 or use a reaction time of ½ second.

5. A PTO shaft 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 Activity 4.

_____ revolutions before reaction to pull away

6. Make the same calculation from Activity 5 using a 1,000-RPM PTO shaft as the speed of the machine.

_____ revolutions before reaction to pull away

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Age-Appropriate Tasks

Learning Goal

◊ Identify typical growth traits by age-groups and how these traits may affect what jobs and tasks young workers should be assigned

Related Task Sheets

◊ 2.1: Injuries Involving Youth
◊ 2.3: Reaction Time
◊ 4.3: NAGCAT Tractor Operation Chart

Introduction

Farming offers a unique opportunity for children and adolescents to learn the value of hard work, how to handle responsibilities, and how to set priorities. Traditionally, farming has been a family affair with children working alongside family members on the farm. Larger farms may hire youth for work as well. While farm labor has many personal development benefits, there are also many risks involved for young workers.

This task sheet offers guidelines for matching youth farm workers with appropriate farm tasks.

Agricultural Youth Work Guidelines

The Ag Youth Work Guidelines help parents and employers determine what tasks are appropriate. These guidelines were developed under the direction of the National Children's Center for Rural and Agricultural Health and Safety. The guidelines assist adults in assigning farm jobs to children age 7 to 16 years who are living or working on farms. Employers should also be aware of the guidelines. Visit the Cultivate Safety website (see Resources below) for more information about the guidelines. These guidelines provide agricultural task assignment recommendations for youth based on research and take into consideration:

◊ Child growth and development
◊ Acceptable agricultural practices
◊ Child injury prevention
◊ Agricultural safety

Guideline categories include tasks ranging from tractor operations to animal handling as well as manual labor tasks such as sweeping and lifting.

Everyone develops differently. As you gain more experience, your skills and knowledge will continue to develop.

Being assigned a developmentally appropriate task considers cognitive, perceptual, and physical stages of development. Cognitive development includes how you absorb and process information, how you make decisions, and your attention span. Perceptual development includes how you use your judgment. This involves estimating risks and evaluating hazards. Physical development deals with your strength, reach, balance, and coordination.

It is important to understand your limitations as you develop toward adulthood. Refer to the table below to review development stages based on age. The table provides details on

common injuries and prevention strategies. The most important point to remember is that you should be assigned a developmentally appropriate task.

All of us go through growth phases. Our physical and mental maturity may not match our work assignment.

Age	Typical Death and Injury Risk Scenarios	Age-Appropriate Tasks
12–13 Years Old (Early Teens)	◊ Machinery entanglements ◊ Head and spine injuries from vehicle collisions ◊ Falls ◊ Sprains	◊ Hand raking and digging ◊ Limited power tool use with supervision ◊ Handling/assisting with animals
14–15 Years Old (Young Teens)	◊ Machinery entanglements with amputations from PTO, augers, turning parts, and power tools ◊ Head and spine injuries from vehicle collisions ◊ Falls ◊ Hearing loss from machinery ◊ Animal handling incidents ◊ Tractor overturns ◊ Roadway crashes or mishaps	◊ Equipment maintenance ◊ Manual feeding of livestock ◊ Operating non-articulated tractors for field work, including those with implements that are three-point mounted, use remote hydraulics, and/or are PTO-driven ◊ Raking hay ◊ Operating a pressure washer ◊ Operating lawn mower or garden tractor
16–18 Years Old (Older Teens)	◊ Machinery entanglements with amputations ◊ Falls from machines and structures ◊ Hearing loss from machinery ◊ Animal handling incidents ◊ Tractor overturns ◊ Roadway crashes or mishaps ◊ Added risk if experimenting with drugs and/or alcohol	◊ Ordinary use of tractors, self-propelled machinery, augers, elevators, and other farm equipment ◊ Pulling oversized loads, simultaneous use of multiple vehicles, and application of chemicals with specific training and close supervision

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

Supervision is an important factor for any task assigned.

Figure 2.4.a. Taking chances with motorized vehicles may be fun, but the odds of an injury or death increase greatly when risky behavior is substituted for correct operation of ATVs, dirt bikes, and tractors. Credit: National Children's Center for Rural and Agricultural Health and Safety

Figure 2.4.b. Young muscles and joints may be strained and sprained trying to move heavy loads. Animals pose their own special risks when being moved as well. Credit: National Children's Center for Rural and Agricultural Health and Safety

Job Safety Analysis

Job safety analysis (JSA) is a technique that helps parents and employers identify hazards and eliminate or minimize them by providing a written set of safe-job-task steps for you before the job is performed. Jobs that can be broken down into a few simple and safe steps are most suitable for JSA. Job safety analysis should be included with good initial instruction and close supervision.

Type of job: _____

Date: _____

Personal protective equipment to be worn:

_____

Basic job steps:

◊ Break the job down into steps. Each of the job's steps should accomplish a major portion of the job. Everything related to one logical set of movements is part of each job step.
◊ JSA works best for jobs that can be broken into four to six steps.
◊ Be sure to list all steps even if a particular step may not be completed each time. For example, when hitching a wagon to a tractor, a jack stand may remove the need for aligning the tongue with the tractor drawbar. However, because not all wagons will have a jack stand, include this step in the JSA.

Potential hazards:

◊ Hazards are potential dangers. Oil on the floor is a hazard.
◊ Examine each step of the job to find and identify hazards—actions, conditions, and possibilities that could lead to an injury.
◊ It is not enough to find the obvious hazards. It is also important to look at the entire environment and find every conceivable hazard that might exist.
◊ Be sure to list health hazards too. Even though harmful effects may not be immediate, they are still hazards. A good example of a health hazard is dust from moldy hay or silage that sets up a sensitivity to the mold.

Recommended action or procedure:

◊ Using the two previous lists as guides, decide which actions are necessary to eliminate or minimize the hazards that could lead to an injury or occupational illness.

- ◊ List recommended safe operating procedures on the JSA form. In addition, list required or recommended personal equipment for each step of the job.
- ◊ Be specific. Say exactly what needs to be done to correct the hazard. A good example would be, "Lift using your leg muscles." Avoid using general statements like, "Be careful."
- ◊ Give a recommended action or procedure that eliminates or minimizes every hazard.

Guidelines for age-appropriate tasks are useful tools and can lead to mature actions of the safety-conscious youth worker.

Figure 2.4.c. Machinery, ATVs, and falls account for most farm injuries and fatalities. Youth who will work with machinery, ATVs, and agricultural structures must be trained and have guidance to be safe workers. Credit: National Children's Center for Rural and Agricultural Health and Safety

Figure 2.4.d. Youth workers assigned to supervised tasks can learn safe, productive agricultural work habits. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Use the Cultivate Safety website to locate the guidelines for operating a tractor. Print the guideline and answer all the questions for yourself. Share this information with your parents and tractor safety instructor or leader.
2. Use the Cultivate Safety website to explore other guideline task sheets that may focus on jobs you will do.
3. Write a short story about a hazardous situation you have encountered and how you approached that hazard based on your stage of development at that time. Did your immaturity as a youth influence the outcome?
4. Ask your class or club members to relate stories of hazardous incidents they encountered and how they handled them.

Note: Youth who are age 12 or 13 may complete studies of safe tractor operation and complete the written exam, but they cannot take the skills or driving exams or receive a certificate under the Hazardous Occupations Order in Agriculture program.

Resources

Cultivate Safety website, **cultivatesafety.org**. National Farm Medicine Center and National Children's Center for Rural and Agricultural Health and Safety.

Penn State Extension "Children and Safety on the Farm" online article, **extension.psu.edu/children-and-safety-on-the-farm**.

Severe Weather

Learning Goal

◊ Recognize the effect that severe weather has on safe work practices

Related Task Sheets

◊ 1.1: The Work Environment
◊ 2.5.1: Heat and Sun
◊ 2.5.2: Cold Weather
◊ 2.5.3: Lightning, Tornadoes, and Rain

Introduction

Agricultural work is completed under various weather conditions. Crops must be harvested, livestock must be tended, and daily routines need to be completed. Hot or cold, rain or shine, some amount of work will continue. Safe work must still be observed under any weather-related condition.

This task sheet will discuss how to recognize severe weather and the effects of such weather on the farm worker. Additional task sheets in Section 2.5 will present safety precautions for heat, cold, sun exposure, lightning, wind storms, and rain.

Summer Weather

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 attention to weather hazards. See Task Sheet 2.5.1.

High Temperatures

Exposure to high summer temperatures can cause illness. Heat cramps, heat exhaustion, and heat stroke are serious problems.

◊ Heat cramps: Symptoms are leg and stomach cramps.
◊ Heat exhaustion: Symptoms are cool, moist, pale or flushed skin, headache, nausea, dizziness, weakness, and exhaustion.
◊ Heat stroke: Symptoms include red, hot, dry skin; changes in consciousness; rapid, weak pulse; and rapid, shallow breathing. Heat stroke can result in death if not treated immediately.

High Humidity

Excessive humidity means that moisture evaporation slows down. Perspiration helps to cool the body as it evaporates. In high humidity, the body continues to lose moisture, but the cooling effect is not felt.

Thunderstorms and Lightning

Cold-weather fronts bring cooler air into contact with warm air masses. Severe thunderstorms result; lightning can happen. On average, 93 people are killed each year by lightning.

Tornadoes

Tornadoes are vertical funnels of rapidly spinning air and can create wind gusts up to 250 mph. They are usually associated with thunderstorms and often are accompanied by hail. During a touchdown of the funnel it may sound like an approaching freight train. Every year tornadoes kill about 70 people and can cause upward of $40 million in property

damage. Must tornado deaths are caused when the victims are struck by flying debris.

Figure 2.5.a. 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.

Severe weather can occur anytime of the year.

Winter Weather

Winter chores on the farm must be done regardless of the weather. Winter cold brings different hazards. Frostbite, hypothermia, and loss of traction all lead to hazardous work conditions (see Task Sheet 2.5.2).

Frostbite

This health hazard occurs when body tissue freezes. Medical attention is needed as soon as possible.

Hypothermia

Hypothermia involves a general cooling of the entire body. When the body cools down, normal processes cease to function properly. Gradual warming of the victim is necessary, as well as immediate medical treatment.

Loss of Traction

Winter weather affects footing—for both people and animals. Tractors that can pull heavy loads under normal circumstances now slip and slide. Slips and falls make up a majority of injury incidents, which may result in fractures, spinal or even head injuries. Walking on slippery surfaces can result in a severe injury. Observing extra care and taking extra time when moving machinery, livestock, and ourselves becomes more important on ice-covered surfaces.

Frostbite destroys body tissue.

Figure 2.5.b. 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 the skin can freeze.

Safety Activities

1. Call your nearest TV or radio weatherperson and ask for an explanation of humidity in the atmosphere.
2. Use the Internet to define heat index (apparent temperature).
3. Use the Internet to define wind chill.
4. Contact your local emergency preparedness officials to learn what signals or warning sirens are used in your community to announce impending weather or other emergencies.
5. With your family, develop an emergency action plan for dealing with high wind or tornado conditions. Practice the plan at least once per year with the entire family.

Reference

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Heat and Sun

Learning Goals

- Understand the health risks of working in the summer heat and sun
- Prevent health risks while working in the summer heat and sun

Related Task Sheets

- 1.1: The Work Environment
- 2.5: Severe Weather
- 2.7: Personal Dress

Introduction

Spring and summer are often busy times outdoors on the farm. Sun exposure, high temperatures, and humidity can create hazardous conditions if proper precautions are not taken. Safe work must be observed under all weather-related conditions.

This task sheet will discuss safe work in the heat and humidity of the summer season. Skin cancer, heat stroke, eye damage, and dehydration are health problems that farm workers must understand and learn how to prevent.

Health Risks From the Sun

All farmers and their workers must pay attention to the problems posed by farm work during the summer season. Health risks increase from overexposure to the sun and heat and include:

- Sunburn/skin cancer
- Ultraviolet (UV) light damage/eye damage
- Dehydration
- Heat stroke

Sunburn/Skin Cancer

While working on most farms, you may 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 exposure to the sun increases, so does the chance of developing skin cancer.

Preventing Sunburn and Skin Cancer

Protect your skin from the harmful effects of the sun by dressing properly and using sunscreen. Long sleeves, long pants, a neckerchief, and a broad-brimmed hat will protect your skin while working in the sun.

A sunscreen with an SPF (sun protection factor) rating of at least 30 is recommended for areas that cannot be protected by clothing. The higher the SPF, the more protection offered. Use sunscreen according to directions on the label.

The American Cancer Society provides information about skin cancer. Contact information for this organization is available on the Internet.

Note: Constant exposure or continually being exposed to the sun from working outdoors without protection can increase the risk of skin cancer.

A worker suffering from sunburn is not a productive worker.

Figure 2.5.1.a. Recommended clothing and skin care precautions for summer sun exposure. Illustrations by Jeff Mathison (left) and : National Children's Center for Rural and Agricultural Health and Safety (right)

UV Rays and Eye Damage

The eye functions to control entering light and focus an image on the optic nerve. Any damage limits the ability of the eye to function properly, and we lose some of our sight. The sun produces different kinds of light:

- UV invisible radiation
- Bright or intense light
- Blue light (a visible light)

The bright sun can damage the eye through the effects of UV (ultraviolet) 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. We cannot focus clearly in this intense light. Intense glare leads to eye strain and fatigue. Prolonged exposure to blue light is believed to age the retina of the eye, which can result in an increased risk of blindness.

Protecting the Eyes

Protect your eyes from the harmful effects of the sun by wearing the correct type of sunglasses. Sunglasses that block or absorb the sun's UV rays are best. Sunglasses are rated according to their capability to block or absorb UV radiation. Look for terms such as "blockage" or "absorption," not just "protection," on the label. A UV rating of 100 is preferred.

Blue light blockers appear as tinted lenses in our glasses. These lenses alter the blue and green colors to reduce glare without making the world appear darker. To block the blue color, a yellow tint must be used. If you often work in bright, glaring conditions, these sunglasses can be helpful.

Several types of sunglasses are made to meet different needs:

- Regular lenses reduce brightness evenly.
- Polarizing lenses reduce glare.
- Photochromic lenses become darker in bright light.
- Mirror lenses reflect light.

Note: The price tag of sunglasses is not a measure of their blockage or absorptive value.

Sunglasses are not just to make you look cool; they must protect your eyes.

Figure 2.5.1.b. Sunglasses are available in spectacle or clip-on versions. Look for the UV rating of 99 to 100 for "blockage" or "absorption." The word "protection" does not guarantee that the sunglasses will block or absorb UV rays.

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 3 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 electrolytes (minerals) that replenish those lost from our bodies when we sweat.

Regular soft drinks do not meet our nutrient needs. To replenish our electrolyte needs, we must eat properly before going to work and drink plenty of liquids while working.

Heat Stroke

Exposure to summer heat and humidity can cause serious illness. Health risks from heat occur when the body cannot cool down by

Figure 2.5.1.c. Water is a nutrient we need. It cools the body, carries nutrients, and flushes waste from the body.

sweating or make up the fluids and minerals lost through perspiration. Each year an average of 175 people die 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 and a rash develops. Cotton clothing can help wick the moisture away from the skin. Use corn starch to treat the rash.
- Heat cramps. Leg and stomach cramps are caused by loss of body fluids due to sweating. Drink cool water often to cool the body. Massage the cramps.
- Heat syncope. Fainting from the heat can occur. Help the victim lie down in a cool spot, and elevate their legs to improve circulation. Let them rest there.
- 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. Have the victim go to a cool place, lie down with their feet elevated, and drink plenty of cool fluids. Medical help should be summoned.

◊ Heat stroke. This 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 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 that requires immediate medical care.

Effects of Humidity on Sweating

Evaporation rates are reduced with excessive humidity. Evaporation of water and sweat has a cooling effect. Without this cooling effect, high temperatures actually feel higher. Heat index charts show "apparent temperatures," which compare air temperature with humidity.

Preventing Heat Illness

Follow these guidelines to prevent heat illness:

1. Drink water 4 cups of water per hour. Do not wait to be thirsty.
2. Avoid caffeinated and other drinks that dehydrate.
3. Wear appropriate summer clothing that fits loosely and reflects the sunlight.

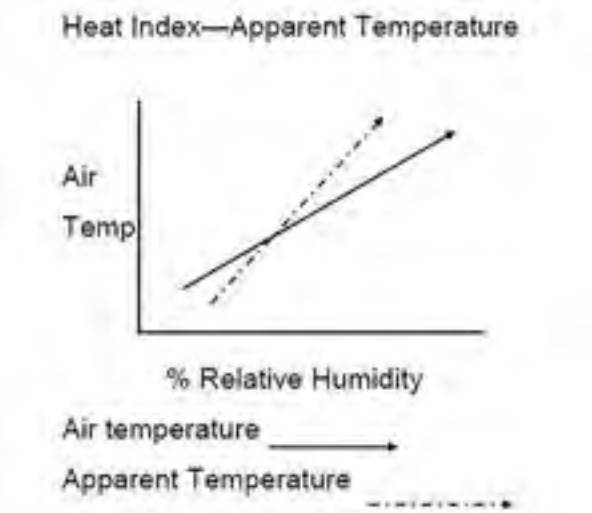


Figure 2.5.1.d. As humidity levels increase with rising temperatures, the apparent temperature (heat index) may appear higher or lower than the reported temperature. Credit: Penn State Extension Ag Safety Team

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.

Safety Activities

1. Type "heat index chart" into any Internet search engine to locate information on a heat index (apparent temperature) chart. Then answer the following questions:
   a. On a day that is 90°F with a relative humidity of 70 percent, the heat index is degrees.
   b. On a day that is 95°F with a relative humidity of 50 percent, the heat index is degrees.
   c. On a day that is 85°F with a relative humidity of 85 percent, the heat index is degrees.
2. Download the OSHA-NIOSH Heat Safety Tool Smartphone App from **www.osha.gov/SLTC/heatillness/heat_index/heat_app.html**. Search for your local conditions and list precautions for the current local work conditions.

Cold Weather

Learning Goals

- Understand the health risks of working in the winter cold
- Understand how to prevent health risks while working in the winter cold

Related Task Sheets

- 1.1: The Work Environment
- 2.5: Severe Weather
- 2.7: Personal Dress
- 3.4: Working with Livestock

Introduction

Farm work does not stop for winter cold. Many work tasks must be competed, such as feeding/caring for livestock, moving grain to market, repairing equipment, preparing for spring planting, or clearing snow or ice from travel areas at the farm site. Working outdoors when weather conditions are adverse takes special care and many considerations to stay safe. Cold, snow, ice, sleet, or rain can create very hazardous situations. Safe work habits must still be practiced under these conditions.

This task sheet will discuss how to recognize the effects of cold weather on the farm worker. Frostbite, hypothermia, and slip or fall hazards must be understood and safe practices should be followed.

Winter Health Hazards

Despite the winter weather, there are still many jobs needed to be done on the farm. Winter weather offers different hazards with which to contend, including frostbite and hypothermia. Our bodies may become accustomed to working in the cold, but exposure to low temperatures, icy conditions, and wintry wind can be hazardous. For example, slippery conditions affect our ability to safely handle equipment and livestock.

Frostbite

Frostbite occurs when body tissue becomes frozen. Skin that feels numb should send the message to the outdoor worker that the skin is too cold and in danger of further damage.

To prevent frostbite, pay attention to the low temperatures and how your skin is reacting. Covered skin is at risk for frostbite as well.

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.

Hypothermia

Hypothermia occurs as the body's temperature drops below 96 degrees. Exposure to severe cold causes this condition. Everyone is familiar with the hypothermia reported when someone falls through the ice. Extreme cold can produce weakness, drowsiness, or confusion, which can lead to further exposure and eventually death.

To prevent hypothermia, dress in layers to help trap air between the clothing. Air has an insulation value. Wear a head covering as well.

Proper winter dress should keep you warm, not hot, and also fit well for safe work around equipment and livestock.

Figure 2.5.2.a. 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 becomes chilled. Illustration by Jeff Mathison

High winter winds coupled with low temperatures may result in a wind chill advisory.

Loss of Traction

Winter weather brings icy and muddy conditions. Footing is more difficult for people and livestock. Tractors that can pull heavy loads under normal circumstances may slip and slide. Livestock can slip and fall and be injured. Animals being moved on slippery surfaces can slip into the worker. Consider these extra precautions:

- ◊ Footwear must have treads that will provide traction.
- ◊ Use traction chains on tractor tires under extremely icy conditions.
- ◊ Operate the tractor carefully and more slowly than when weather conditions are dry.
- ◊ Recognize that vehicles traveling on public roadways may need greater distances to slow to a stop as they approach farm equipment sharing the road.
- ◊ Move livestock slowly to prevent the animal from falling or sliding into you.

Winter activities require slower, more deliberate movements to prevent injury.

Loss of traction means loss of control.

Safety Activity

1. Using the Internet, locate the National Weather Service Wind Chill Chart. Use this chart to answer the following questions:
   a. On a day that is 30°F with winds of 15 mph, the temperature will feel like _____ degrees on your skin.
   b. On a day that is 20°F with winds of 15 mph, the temperature will feel like _____ degrees on your skin.
   c. On a day that is 10°F with winds of 30 mph, the temperature will feel like _____ degrees on your skin.
   d. If the temperature is 10°F and you are driving a snowmobile at 40 mph, what is the wind chill factor in degrees?

Reference

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

HOSTA Task Sheet 2.5.3

Lightning, Tornadoes, and Rain

Learning Goal

◊ Work safely during severe weather conditions

Related Task Sheets

◊ 1.1: The Work Environment
◊ 2.5: Severe Weather
◊ 4.12: Tractor Stability
◊ 4.13: Using the Tractor Safely

Introduction

Severe weather can develop rapidly under the right conditions. Weather forecasts will help estimate the arrival of adverse conditions. Weather conditions can change quickly while you are completing agricultural work, so it is important to understand the necessary precautions to keep you safe. Thunderstorms, rain, lightning, or tornadoes present serious hazards and require you to practice safe work habits while completing work outdoors. Work may be delayed when a weather event occurs.

Field work puts stress on everyone, especially if the weather report predicts that stormy conditions will interfere with that effort. This may create a response to "hurry" which may lead to making poor decisions resulting in an injury. Your priority should be safety. Knowledge of weather patterns and how they change can improve your safe work habits.

This task sheet discusses lightning, tornadoes, and rain and the risks they pose to safe farm work.

Safety must always be a top priority in farming regardless of weather factors.

Lightning

Sudden rainstorms are often preceded by violent lightning storms. Lightning is caused by a buildup of static electricity in the air. Positively charged molecules rise into the sky, and negatively charged molecules fall to the bottom of clouds. The negatively charged particles are attracted to the positively charged particles in a flash of lightning.

Lightning fatalities rank second to floods in weather-related deaths. Lightning energy as high as 100 million volts and as hot as 50,000°F is released within half a second. Lifelong disability and death can result from exposure to the extreme levels of electricity and temperature.

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 only occurs under stormy skies.

Truth: Lightning can strike 10 miles from a storm.

Precautions to Take

Take these precautions if severe thunderstorms are forecast:

- ◊ Check the weather forecast before starting to work.
- ◊ Observe threatening clouds and increasing winds that begin to develop.
- ◊ 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, you should already be moving 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 that is away from hilltops, trees, or utility lines.
- ◊ Use closed buildings for shelter if possible. Do not use items connected to plumbing or house wiring.
- ◊ Tractors with cabs and vehicles can be used for shelter.

Figure 2.5.3.a. Lightning strikes can be fatal. Take shelter indoors if possible. Do not seek shelter beneath trees or near utility lines.

Hurrying to beat a storm during harvest increases the risk of injury.

Tornadoes and Wind

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. Eastward-moving cold-weather fronts colliding with warm, moist weather form ideal conditions for high winds and tornadoes to develop.

These conditions can occur rapidly. Some areas of the country are more prone than others to conditions of high winds and tornadoes. Tornadoes accompany thunderstorms. The following signs indicate a potential for a tornado:

- ◊ Dark, often greenish sky
- ◊ Large hail
- ◊ A cloud that looks like a wall
- ◊ A loud roaring sound

Be prepared to respond to these weather signals. With early warning systems in place throughout the United States, tornado deaths have been greatly reduced. Know what the changing weather means to your safety. Remember these points in a tornado:

- ◊ Understand the radio and local siren warnings used to sound impending weather emergencies.
- ◊ If a tornado "watch" is issued, remain alert to 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.
- ◊ If caught outdoors in high winds or tornadoes, seek a ditch or low spot for protection. Lie face down with your hands over your head.
- ◊ If you find shelter in a building, go to the basement or an inner room. Stay away from outside walls, which may collapse, and stay away from windows, which may shatter.

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: 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.

Tornadoes are possible from April to November in parts of the United States.

Figure 2.5.3.b. While tornadoes do not occur in all areas of the United States, 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.

Rain and Rainstorms

Regular rainfall is necessary for crop growth. Periods of drought reduce yields and cause anxiety for farmers. Excessive rainfall delays planting and harvest, and frustration again builds. Rain is necessary for success, but rain and rainstorms affect farm safety. Examine these points:

- ◊ Excessive rain causes reduced traction. Tractor steps may be mud covered. Fields may be slippery. Tractors can become stuck (see Task Sheet 4.13).
- ◊ 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 loss.
- ◊ Long periods of weather extremes frustrate farm growers. Unsafe acts can result as producers attempt to hurry to complete the work.

Think about the scenarios described. Have you seen these effects of weather?

Figure 2.5.3.c. Excessive rainfall delays crop operations, reduces traction, and builds frustration.

National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA) of the federal government conducts weather and environmental observations 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 are available for purchase from many stores. These radios continuously broadcast updated weather warnings and forecasts. The radios' average range is 40 miles depending on topography. Some NOAA radios have a feature that automatically sounds a tone when a watch or warning is issued in your area. The National Weather Service also provides an app for cell phones; see **https://www.weather.gov/wrn/mobile-phone**.

U.S. Weather Notification System

The National Weather Service issues daily forecasts and long-range weather outlooks. This service also decides when to issue severe weather watches. These notices include "watches" and "warnings."

- **Severe weather watch:** indicates conditions are favorable for the development of severe weather, such as tornadoes thunderstorms, blizzards, and potentially damaging wind or hail.
- **Severe weather warning:** indicates that a tornado, severe thunderstorm, or winter storm is in the immediate vicinity. People who are outdoors should find shelter as soon as possible.

Figure 2.5.3.d. Clouds can help predict weather. Cloud A is a cumulus cloud. These heaped or lumpy clouds indicate a period of fair weather. Cloud B is a stratus, layered cloud. These layered clouds are full of ice crystals and can also form fog and mist.

Special Note

An individual is responsible for their own personal safety and has the right to take appropriate action when threatened by severe weather. No employer can force you to work in a dangerous situation.

Safety Activities

1. Use the Internet to learn more about lightning and tornadoes. Write a report for your teacher or leader or for extra credit in science class.
2. Develop a severe weather emergency plan for your family or farm if one does not already exist.
3. If a weather emergency plan does exist, have the family or farm employees gather to review and practice the plan together.
4. After a rainstorm, clean the steps to each tractor and implement ladder to reduce slip-and-fall hazards.
5. Make a cloud project. You will need a large clear plastic jar, a small metal tray, ice cubes, and hot water.
   Step 1. Fill the jar half full of hot water (be careful).
   Step 2. Place some ice trays on a metal tray on top of the jar.
   Step 3. Observe the air space in the jar beneath the tray. Air and water vapor inside the jar next to the tray is cooled, condensing into water droplets (a cloud).

Resources

Lightning Protection Institute website, **www.lightning.org**.

National Lightning Safety Institute website, **www.lightningsafety.com**.

National Oceanic and Atmospheric Administration website, **www.noaa.gov**.

National Weather Service website, **www.nws.noaa.gov**.

Housekeeping

Learning Goal

◊ Recognize how good housekeeping helps prevent health and safety hazards

Related Task Sheets

◊ 1.1: The Work Environment
◊ 2.10: Personal Protective Equipment
◊ 3.3: Respiratory Hazards
◊ 3.3.1: Respiratory Protection
◊ 3.5: Agricultural Pesticides
◊ 3.6: Electrical Hazards
◊ 3.7: Fire Safety
◊ 3.7.1: Fire Prevention and Control
◊ 3.7.2: Hay Storage Fires
◊ 3.13: Chemicals Used on Farms

Introduction

Tractors and machinery are not the only sources of occupational hazards on a farm. Cluttered work areas such as shops and barns also create hazards for the worker.

This task sheet discusses the relationship between good housekeeping and safety. Recognizing housekeeping needs, including storage use and cleanup practices, is a must for the safety of every worker.

Importance of Housekeeping

Lack of housekeeping creates hazards. 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 and unplanned methods of work often indicate an unsafe place to work and increase the opportunity for injuries. Several topics are important when discussing good housekeeping on the farm, including:

◊ Worksite adequacy
◊ Environmental hazards
◊ Storage needs
◊ Cleanup practices

A clean farmstead is a safe farmstead.

Worksite Adequacy

The worksite must be safe from the beginning of the workday. Observe these points:

◊ Are aisles and passages wide enough and high enough for safe movement?
◊ Is there adequate lighting?
◊ Is there adequate ventilation?
◊ Are there slip-resistant floors and ramps?
◊ Are pits and floor openings covered?
◊ Are sharp edges eliminated?
◊ Are exits defined 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 young workers can develop the skills and safe attitude necessary to maintain the facilities. Shop cleanup is a valuable job skill. Here are some things you can do to make facilities safe and healthy:

◊ Report unsafe work areas.
◊ Report malfunctioning lighting.
◊ Put tools, materials, and unused supplies in their correct places.
◊ Sweep floors.
◊ Clean oil and grease spills from floors.
◊ Clean sinks and toilet facilities.

If you are not assigned to a specific job, make yourself a valuable employee by doing some housekeeping chores.

Figure 2.6.a. 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 pesticides. Credit: Penn State Extension Ag Safety Team

Figure 2.6.b. Barns and machine shops are dusty places. Unprotected electrical boxes can collect large amounts of dust and debris. This can start a fire by causing an arc across the conductors and igniting the debris. Practice good housekeeping and use electrical safeguards. Credit: Penn State Extension Ag Safety Team

Environmental Hazards

The farm environment has many health risks that can be reduced by good housekeeping. Chemicals, dusts, molds, welding rays, noise, heat, cold, and excessive moisture are common. Each poses a special problem. Chemicals, molds, heat, cold, and noise will be discussed in other task sheets.

Dust

Smaller or fine flammable materials, often called kindling or tender, will burn hot and quickly. These materials have a smaller surface area and, depending on their properties, will have lower ignition temperatures. These items are what catch fire first before a fire can be started with the larger structural components of a building. Dust, which is dry, has a low ignition temperature. Dust can burn explosively much like the fumes from gasoline.

Dust explosions have occurred in feed mills and at grain storage elevators. The explosion usually occurs due to electrical sparking igniting the dust particles. Sparks from welding can also ignite dust and chaff. You may notice that special dust- and moisture-proof motors and controls are used to prevent fires and explosions in many agricultural applications.

You cannot remove all dust from the farmstead. No one would ask you to do that task, but unnecessary dust buildup near sources of fire increases the risk of fire. Some cleaning near these sources could prevent a fire.

Dust can explode!

Welding Rays

Defective welding helmets, cracked welding lenses, and torn welding curtains can create eyesight damage risks. Repair welding helmet lenses and welding curtains as part of the housekeeping work routine.

Excessive Moisture/Slippery Floors

Water, oils, or 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 clean the area. You should place a warning sign or barricade at the location until the floor is dry and safe.

Storage

Proper storage of materials creates an organized and safe work space. No one wants to waste time looking for tools or materials. Safe storage prevents 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 stock, such as wood or pipe, should be stored on racks designed to hold long pieces. Long stock stored under benches and sticking out may cause a leg injury to people passing by. Heavy objects should be stored as close to the floor or ground as possible to prevent them from falling on people.

Fuels and Lubricants

Fuel storage is an important housekeeping chore. Liquid fuels have a flash point. A flash point is that point at which temperatures are high enough to ignite a gaseous fuel source. The fuel may also be volatile. Volatility is a property of fuels in which they produce vapors that easily ignite.

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

Work areas cannot be perfectly clean at all times, but they can be made safer to work in at all times. Cleaning as your work progresses will eliminate the need to do major cleaning chores later and will make for a safer work space. Use these ideas for cleanup:

1. Clean all spilled material immediately. Avoid cleaning procedures that would make those materials become airborne inhalation hazards.
2. Place rags soaked in oil, grease, paint, and/or solvent in metal containers to reduce fire risks.
3. Use hand cleaners and disinfectants before eating or drinking.
4. Dispose of animal health equipment tools and supplies as directed.
5. Manure and mud are slippery. Both can be brought into the shop area on machinery. 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.

Safety Activities

1. Define "ignition point," "flash point," and "volatility."
2. Survey a farm shop and make a list of housekeeping items that you judge to be potentially hazardous.
3. Survey the school's agricultural shop or industrial technology shop (with the instructor's permission) and list housekeeping items that are potentially hazardous. If your school does not have such an area, ask the chemistry teacher to show you the storage facilities for that subject area.
4. Bring some very dry, fine dust from the barn or farm shop to a safe place where air currents are minimal. Sprinkle small amounts of the dust over a lighted candle. What happens?
5. Bring some very dry, fine metal filings from the farm shop to a safe place where air currents are minimal. Sprinkle small amounts of the metal filings over a lighted candle. What happens?

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Personal Dress

Learning Goal

◊ Dress safely for work

Related Task Sheet

◊ 1.1: The Work Environment
◊ 2.1: Injuries Involving Youth
◊ 2.3: Reaction Time
◊ 2.10: Personal Protective Equipment

Introduction

Dressing appropriately not only communicates your professionalism but can also impact your safety. When a person goes to work, they should dress for the work they will do. You would not look like a good candidate for work if you showed up at a farm in your sandals. Some workplaces have dress codes that are design to keep you safe. Think about your safety as you dress for work.

This task sheet discusses personal dress choices for safe work. Ask your employer if specific work dress is expected.

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

What Should I Wear?

Some young workers might rebel about the idea that someone is going to tell them what to wear to work. The latest fashions or stylish clothes will not make you a better or safer worker. Dressing safely decreases your chance of injury or death on the job. Before starting a job, know the requirements you will be performing and dress accordingly. During the summer, mowing fields or baling hay may mean several hours in the sun. Overexposure to the sun is a serious hazard for young workers. A long-sleeved shirt, a hat that protects your ears and neck, and sunblock are all part of safe dressing. Here are some other approved safety practices for how you should dress for work:

1. Wear snug-fitting clothes that are in good repair. Loose clothes, dangling threads, ripped sleeves and cuffs, and drawstrings can easily become entangled in machinery or be snagged on tractor parts.
2. Leave jewelry at home. Jewelry can be caught in machine parts or snagged on the tractor as you mount or dismount.
3. Wear hard shoes with slip-resistant treads. Sandals or sneakers offer little protection from livestock trampling, briars, nails, welding sparks, falling lumber, or other objects. Check to see if steel-toed work boots are necessary.
4. Tie shoes snugly. Loose shoestrings can be caught in rotating parts.
5. Tie long hair out of the way. Tying or covering long hair will prevent it from being pulled into turning parts of machinery, saving you from being scalped.

Figure 2.7.a. Not dressing safely for the job exposes you to the risk of injury or death. Illustration by Jeff Mathison

Figure 2.7.b. Safely dressed workers wear the clothing and equipment needed to do the job without risking danger to themselves. Illustration by Jeff Mathison

6. Wear long pants that are the correct length. Long pants that fit properly and are in good repair will protect your legs from sunburn, splinters, briars, and thistles.

Under the U.S. Equal Employment Opportunity Commission, an employer may request an employee to refrain from wearing religious dress or grooming practices based on workplace safety, security, or health concerns so long as the practice can be justified to pose an undue hardship on the operation of the business. For examples describing certain cases and considerations if the employer violated Title VII, see **https://www.eeoc.gov/eeoc/publications/qa_religious_garb_grooming.cfm** question 12 or contact a human resources expert.

If you do not know what clothing to wear for a job, ask your employer.

Safety Activity

1. Find the following words in the word search:
   DANGLING SLEEVE

   LONG HAIR TIED

   SHOESTRINGS

   DRAWSTRINGS

   LOOSE CUFFS

   SNUG CLOTHES

   HARD SHOES

   NO JEWELRY

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Safe Personal Dress

S	E	H	T	O	L	C	G	U	N	S	E
V	G	Y	A	K	M	Z	W	G	H	P	V
F	W	N	A	R	N	W	Q	O	U	O	E
D	N	U	I	H	D	D	E	C	P	F	E
E	D	F	K	R	X	S	Q	V	D	X	L
T	G	Z	K	X	T	A	H	Y	Z	Y	S
D	H	O	P	R	I	S	L	O	R	L	G
A	G	R	I	W	H	Z	W	L	E	F	N
F	Z	N	Q	P	J	L	E	A	G	S	I
J	G	J	V	P	C	W	Y	X	R	M	L
S	F	F	U	C	E	S	O	O	L	D	G
K	Y	P	Q	J	Q	O	N	A	Q	H	N
D	G	U	O	T	V	H	R	G	V	E	A
L	O	N	G	H	A	I	R	T	I	E	D

Hazard Warning Signs

Learning Goal

◊ Gather hazard potential and safe operation information quickly by understanding hazard warning signs

Related Task Sheets

◊ 4.4: Tractor Instrument Panel
◊ 4.5: Tractor Controls
◊ 4.5.6: Tractor Operation Symbols
◊ 4.6: Preventive Maintenance and Pre-Operation Checks

Introduction

Uniform safety signs are designed to promote and improve personal safety in agricultural workplaces. Safety signs have been developed to warn of farm machinery hazards, but there are also safety signs that apply to other hazards like chemicals. Signal words, sign format, and color combinations all play a role in safety signs.

This task sheet discusses uniform hazard warning signs that farm workers should observe and understand. Use specific owner's manuals to learn more about them.

Safety Alert Symbol

This symbol was created to draw attention to the need for safety. The symbol means:

◊ **Attention!**
◊ **Become alert!**
◊ **Your safety is involved!**

The safety alert symbol is used with agricultural, construction, and industrial equipment. The primary uses of the symbol are in an owner's manual and on hazard warning signs.

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

Good Hazard Warning Signs

Hazard warning signs placed on tractors and machinery serve as quick, easy sources of information. They do not replace an owner's manual. The warning signs make the information readily available and:

◊ Include the safety alert symbol
◊ Warn a person of 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

DANGER

The most serious hazard potential. These are RED.

WARNING

Shows a lesser degree of hazard potential. These are ORANGE.

CAUTION

Indicates a need to follow safety instructions. These are YELLOW.

Hazard signs and symbols provide the most direct information nearest the potential hazard site. Use them!

Pictorials

A pictorial is a graphical representation intended to convey a message without the use of words. It quickly presents a potential hazard situation and a possible result of ignoring this potential danger. When these "picture" messages are seen, ask yourself, "What is the worst thing that can happen to me?" Pictorials 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 help a person to quickly recognize a hazard. Learning what each pictorial is trying to communicate can help you respond to or avoid a serious injury.

Many pictorials have been developed; some are shown and explained here. (Safety signs were provided by the Association of Equipment Manufacturers. For more signs, visit the AEM Pictorial Database at **www.aem.org/safety-and-technical/safety/pictorial-database**.)

Pictorials pose the potential hazard to us, as well as the consequences of ignoring the hazard warning.

Figure 2.8.a. Crushed by bale.
Credit: AEM Pictorial Database

Figure 2.8.b. Electric shock hazard.
Credit: AEM Pictorial Database

Figure 2.8.c. Crushing of feet.
Credit: AEM Pictorial Database

Figure 2.8.d. Body entanglement.
Credit: AEM Pictorial Database

Figure 2.8.e. Falling from [implement, tractor, etc.]
Credit: AEM Pictorial Database

Figure 2.8.f. Fluid injection.
Credit: AEM Pictorial Database

Figure 2.8.g. Runover.
Credit: AEM Pictorial Database

Figure 2.8.h. Entanglement and amputation.
Credit: AEM Pictorial Database

Figure 2.8.i. Overhead loader electric shock.
Credit: AEM Pictorial Database

Figure 2.8.j. Slippery area falls.
Credit: AEM Pictorial Database

Figure 2.8.k. Throw objects and hearing projection.
Credit: AEM Pictorial Database

Safety Activities

1. Go online to the Association of Equipment Manufacturers Pictorial Database at **www.aem.org/safety-and-technical/safety/pictorial-database**, locate the safety signs guidance document, and print out the PDF. Use the information for a class or group discussion.
2. Safety signs are constantly being developed. The AEM safety pictorial guidance document from Activity 1 gives rules for developing safety pictorials. Choose a potential hazard and design a safety sign for that situation. Perhaps someday your sign will be used as an industry standard.
3. Tell your leader, teacher, or employer what the following safety alert signal words mean: CAUTION WARNING DANGER
4. Draw a picture of the safety sign or symbol for each of these:
   a. Hand entanglement in a chain and sprocket drive
   b. Hot engine coolant temperature
   c. Falling into machinery, such as an auger
   d. Entanglement in a belt drive
5. Draw the safety alert symbol here.
6. Develop a hazard warning sign for a potential dog bite on a farm. Draw your sign here.

7. What message does this safety alert sign have for the operator? Try writing the message in as few sentences as possible. Which method—pictorial or written—conveys the message more quickly?

8. Look at Figure 2.8.I. What hazard warning sign would you expect to see in this situation?

Figure 2.8.I. Use the handholds and face the steps when mounting the tractor. Credit: Penn State Extension Ag Safety Team

References

Association of Equipment Manufacturers Pictorial Database, **www.aem.org/safety-and-technical/safety/pictorial-database**.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

"Safety Signs." ANSI/ASAE S441. St. Joseph, MI: American Society of Agricultural and Biological Engineers.

Hand Signals

Learning Goals

- Use the 11 standard hand signals to communicate actions to be taken with the tractor and equipment
- Use standard hand signals for highway use

Related Task Sheets

- 4.2: Tractor Hazards
- 4.5: Tractor Controls
- 4.13: Using the Tractor Safely
- 4.14: Operating the Tractor on Public Roads

Introduction

Keeping a safe distance while assisting a tractor operator is important. However, this can create problems when you need to communicate to the operator where to move the equipment or machine. Noise from machinery and/or the distance between workers often leads to a communication breakdown. An increased risk for hazardous situations can occur.

This task sheet presents 11 standard hand signals adopted by the American Society of Agricultural and Biological Engineers (ASABE) and three signals for public road use. Memorize and use these hand signals. Teach them to others. You will save time and establish safe communications.

Hand signals provide standard communication to all workers.

ASABE Figure 1: 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.

ASABE Figure 2: Come to Me

Raise the arm vertically overhead, palm to the front, and rotate in large horizontal circles.

Example: Someone has opened the gate for the cows to be brought forward. You will signal in this manner.

ASABE Figure 3: Move Toward Me—Follow Me

Point toward person(s), vehicle(s), or unit(s). Signal by holding arm horizontally to the front, palm up, and motioning toward the body.

Example: Use this signal to motion an equipment operator to move toward you to position or move equipment in a crowded area where side visibility is poor.

ASABE Figure 4: Move Out—Take Off

Face the desired direction of movement, hold the arm extended to the rear, and 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. Signal the person to move out for field work.

ASABE Figure 5: Stop

Raise the hand upward to the full extent of the arm, palm to the front. Hold that position until the signal is understood.

Example: The tractor and forage wagon are now positioned for unloading into the silage blower. You signal the operator to stop.

ASABE Figure 6: Speed It Up—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 unit out now; the way is clear. We need to move on.

ASABE Figure 7: Slow Down—Decrease Speed

Extend arm horizontally sideward with palm down; wave arm downward at a minimum 45 degrees several times. Do not move arm above horizontal.

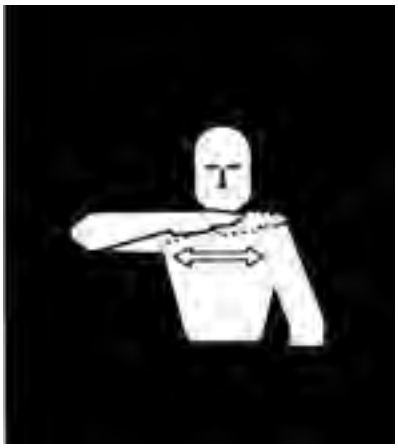
Example: You are going too fast; slow down.

ASABE Figure 8: 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 engine after some adjustment has been made.

ASABE Figure 9: Stop the Engine



Draw right hand, palm down, across the neck in a "throat-cutting" motion left to right.

Example: You need to have the operator stop the engine for some adjustments to the machinery.

ASABE Figure 10: Lower Equipment

Use circular motion with either hand pointing to the ground.

Example: Use this signal to have operator lower high lift or machine header.

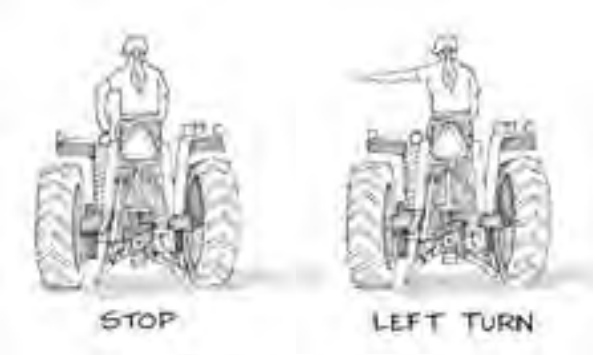
ASABE Figure 11: Raise the Equipment

Make circular motion with either hand at head level.

Example: Use this signal to have operator raise high lift or machine header.

Public Road Hand Signals

Other hand signals provide means of communicating in traffic situations. Use these signals for public road travel or anywhere others may be following you. These signals are standard highway signals to the general public as well.



Safety Activities

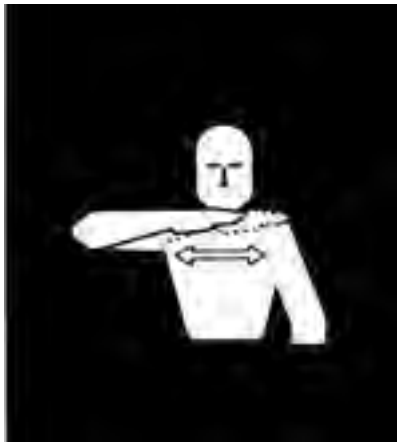
1. Identify each hand signal and give examples of when to use each signal.

Identifies:

An example is:

Identifies:

An example is:



Identifies:

An example is:

2. Demonstrate all 11 hand signals to your leader, teacher, parents, or employer.
3. Demonstrate the hand signals to be used when you are traveling with the transport disk in highway traffic.
   Right Turn Left Turn Stop

References

"Hand Signals for Use in Agriculture." ANSI/ASABE S351. St. Joseph, MI: American Society of Agricultural and Biological Engineers.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Personal Protective Equipment

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

Learning Goals

- Learn when to use specific types of personal protective equipment
- Recognize the symbols that indicate specific types of personal protective equipment

Related Task Sheets

- 2.1: Injuries Involving Youth
- 2.7: Personal Dress
- 2.8: Hazard Warning Signs
- 3.1: Mechanical Hazards
- 3.2: Noise Hazards and Hearing Protection
- 3.3: Respiratory Hazards
- 3.3.1: Respiratory Protection

Introduction

Items of personal protective equipment (PPE) are designed to protect you from injury and illness. Use PPE to prevent injury or damage to your head, eyes, ears, body and feet.

PPE is the last line of defense against workplace injuries, ranging from bruised toes, to the loss of an eye, to death from a falling object hitting you on the head.

This task sheet discusses personal protective equipment, including the symbols that show the need for this equipment.

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). Certified safe eyewear is marked ANSI Z87.1.

Eye protection 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

- Goggles protect against splashes from all types of hazardous liquids.
- Industrial safety glasses protect against flying and pointed projectiles and may come with brow and side-protection panels.
- Face shields protect against splashing and crop debris, but they are not designed for high-impact hazards (projectiles). Use industrial safety glasses under the face shield for complete protection.

Figure 2.10.a. Industrial safety glasses are recommended when you see this symbol. Credit: AEM Pictorial Database

Figure 2.10.b. Goggles with impact-resistant lenses are recommended when you see this symbol. Credit: AEM Pictorial Database

Figure 2.10.c. Face shields are recommended when you see this symbol. Credit: AEM Pictorial Database

Respiratory Protection

Protecting our lungs is vital to our health. Agricultural work exposes the worker to vapors, fumes, and dust. Using a respirator certified by the National Institute for Occupational Safety and Health (NIOSH) is important. An approved dust mask will always have two straps. Make sure that the mask fits snugly around your mouth and nose.

Older devices will be identified with a "TC" number written on the respirator (e.g., TC-23). Newer respiratory protection devices will be identified with N95, N99, or N99.97, which represents the percentage of particles that the filter can trap. See Task Sheet 3.3.1: Respiratory Protection for further information on respiratory protection devices.

Respirators are either air purifying or air supplying.

- **Air-purifying respirators** filter dust, vapors and fumes out of the air you breathe. Air purification from chemical fumes or vapors is necessary. Specific cartridges must be used, and the mask must fit snugly. A single-strap dust mask is not an approved respirator and offers little breathing protection. Eye protection may be needed as well.
- **Air-supplying respirators** are the type firefighters wear when fighting fires. Never attempt to work with an air supplying respirator without extensive training.

Figure 2.10.d. A NIOSH-approved dust mask is recommended when you see this symbol. Credit: AEM Pictorial Database

Figure 2.10.e. A cartridge type mask is recommended when you see this symbol. Credit: AEM Pictorial Database

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

Work spaces where you could bump your head while working are "bump cap areas." Workplaces where someone is working above you are "hard hat areas." ANSI-certified bump caps or hard hats will be marked with the ANSI Z89.1 code.

Figure 2.10.f. When you see this symbol, bump caps will be needed. Credit: AEM Pictorial Database

Figure 2.10.g. When you see this symbol, hard hats are required for head protection. Credit: AEM Pictorial Database

Hearing Loss Protection

Exposure to noise levels varies with jobs and activities. Sound level is measured in decibels (dB). Normal conversation measures 60 dB, while a jet airplane at takeoff measures over 120 dB. If you cannot hear a person who is standing 3 feet away and talking in a normal voice, then hearing protection is needed.

Prolonged exposure to loud noises leads to hearing loss. Hearing loss is permanent unless you wear a hearing aid. Protect your hearing with ANSI-approved ear protection devices.

Ear plugs or acoustic muff style protective devices are two types of hearing protection. Ear plugs fit into the ear, while acoustic ear muffs fit over the ear itself. The preferred ear protection device covers the ear and ear canal.

Figure 2.10.h.
Hearing protection is recommended when you see this symbol.

Never stuff cotton into the ears to reduce noise levels.

Protective Clothing

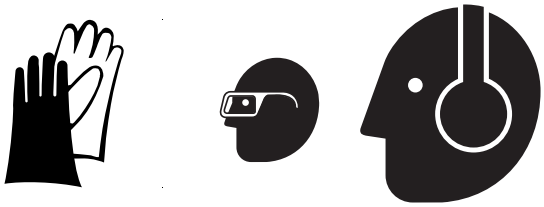
General rules for clothing include shirttails tucked in, jackets zipped or buttoned, and draw strings removed from clothing. Snug-fitting long sleeves and long pants may also be recommended.

Working with a chain saw and logs, cattle and horses, lumber and concrete block, barrels, or 55-gallon drums are a few farm tasks that require foot protection.

Leather gloves are for handling rough or abrasive materials. Neoprene, nitrile, rubber, or barrier-laminate gloves should be used for handling pesticides and solvents (leather does not resist chemicals).

Safety Activities

1. Match the hazard with the PPE needed. (You may select more than one answer.)
   A. Operating a tractor with a faulty muffler
   B. Checking battery fluid level
   C. Grinding a broken bolt



2. Where have you seen PPE symbols on your farm or the farm on which you are employed?
3. Invite a sales or product representative from a safety equipment supply company to demonstrate the correct use of a variety of PPE.
4. Collect a sample of PPE and give a presentation on the proper use and care of the equipment.
5. What types of agricultural jobs is this person dressed to do? Discuss the possibilities with your club, class, leader or mentor.

References

Association of Equipment Manufacturers Pictorial Database. **www.aem.org/safety-and-technical/safety/pictorial-database**.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

First Aid and Rescue

Learning Goals

◊ Learn how to prepare for emergency situations
◊ Learn how to respond to farm injury emergencies

Related Task Sheet

◊ 1.5: National Agricultural Safety and Health Resources

Introduction

Knowledge of first aid and rescue should be part of everyone's safety experience. Hazards and risks can be reduced by careful planning and safe work habits, but injuries can still occur. What can you do if an injury or fatality occurs where you work?

In addition to safe equipment, a safe worksite should include:

◊ A person trained in CPR and first aid procedures
◊ A first aid kit and supplies
◊ An emergency plan, including telephone numbers for services such as 911
◊ A location or site map available for emergency responders

This task sheet discusses first aid and rescue basics; however, it will not make you a professional emergency rescue worker.

Have you been trained in first aid and CPR?

Emergency Contacts

In the event of an emergency, immediately call 911 or emergency medical service (EMS) personnel. Telephone numbers for the following should be posted near the phone or stored in your cell phone:

◊ Fire department
◊ Police department
◊ Ambulance service
◊ Poison control center
◊ HAZMAT regional office
◊ 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. Have this detailed information posted by the phone with the emergency phone numbers. Farm maps should be provided to emergency responders for their files.

Write down the directions to the farm to be read to 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. Injured victims or someone suffering from a heart attack or stroke can be assisted by CPR techniques.

CPR classes are offered by the American Heart Association or the American Red Cross 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 trained, be sure to stay up to date.

Example Scenario

A farm emergency has occurred. You approach the victim to render aid. What must you do? In this case, you must (A) 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 turn off the power, do not touch the victim. If you can disconnect the current, then clear the victim's airway and be sure that the victim is breathing (B). If the victim is not breathing, CPR should be administered (C). Chest compressions and mouth-to-mouth resuscitation must be done properly to assist the person to breathe and maintain a heartbeat. You may wish to enroll in CPR and first aid training to respond to these types of emergencies.

Figure 2.11.a. Check the area to be sure that you are not going to be electrocuted. Credit: Penn State Extension Ag Safety Team

Figure 2.11.b. Clear the victim's airway and be sure that the victim is breathing. Credit: Penn State Extension Ag Safety Team

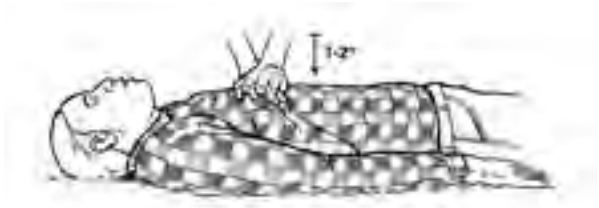


Figure 2.11c. Administer CPR. Illustration by Andy Mylan

First Aid Basics

Non-Life-Threatening Injury

First aid practices for minor cuts, abrasions, splinters, insect stings, snake bites, and burns are easily completed. First aid kits consist of disinfectants, bandages, and light wraps, which are useful until medical help is secured. Exercise care to keep dirt out of open wounds and do not apply any ointment or cream to burns.

Life-Threatening Injury

Trauma, electrocution, severe bleeding, severe burns, and pesticide exposure may be a matter of life and death. The victim needs immediate medical care and may be unconscious. You may become the initial caregiver. See "Farm Family Emergency Response," below.

What can you do? Without training, your emergency response may be inappropriate and could create a liability issue. Do not put yourself

or the victim in more danger. Follow the CABs of first aid after assessing the overall situation:

- Circulation. Blood must flow throughout the body to carry oxygen to the cells. Without oxygen, brain damage can occur in minutes. CPR will be needed if the victim cannot breathe on their own. CPR involves regular chest compressions and breathing assistance. You must be trained in CPR to provide this service.
- Airway. The victim must be able to breathe. Lay the victim flat on their back after checking that there are no broken bones or spinal injuries that could cause further harm. Be sure that the airways (nose, mouth, and throat) are clear. Remove any material from the mouth. Tilt the head and lift the chin to open the airway. Loosening the shirt collar and belt may improve breathing.
- Breathing. Determine if the person is responsive. Shout, "Are you okay?" If there is no response, mouth-to-mouth resuscitation may be needed.

Did you learn how to conduct mouth-to-mouth resuscitation in health class at school?

First Aid Equipment Needs

General purpose first aid kits are readily available. A small, well-maintained first aid kit should be placed on every tractor, farm truck, and major piece of equipment. Larger kits should be located in the farm shop or at home. Replace items that have been used so supplies are always available. At minimum, the small kits should contain:

- 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

Figure 2.11.d. A first aid kit should be kept within easy access of tractors and equipment. Credit: Jeff Mathison

Enroll in a CPR and first aid course to keep your skills current.

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.

Discovery of a victim of an agricultural accident requires immediate action. Three actions are needed.

1. Activate emergency medical services (EMS).
2. Stabilize the scene.
3. Provide patient care.

Activating EMS

You must quickly and calmly determine whether to remain at the site or seek help. Discovering a farm accident means a call for assistance is needed. It is recommended that each farm have a site map located at the farm entrance. Rescue

teams can then assess the location and identify potential hazards.

Stabilizing the Scene

Controlling hazards at the scene that could harm you or cause further harm to the victim is called "stabilizing the scene."

Tractors and machinery can roll farther. Fire and explosions can occur. Hazardous materials could spill or toxic fumes can exist. Be cautious. You may rush to help the victim and become a victim as well.

If the scene cannot be stabilized, but you can still safely approach the victim, try to remove them from the danger. If you suspect spinal injury to the victim, moving them could pose a risk for paralysis or death. Take time to think about the risk to the victim.

Your decisions are important. Think about them, read about these situations, and enroll in CPR and first aid classes to increase your decision-making skills during emergencies.

Providing Patient Care

If you are not trained in CPR, your actions may be limited to ensuring that the victim is breathing and bleeding is controlled. Review the airway information above.

Arteries carry blood away from the heart in pulses. Severed arteries spurt blood. You must apply pressure firmly in that area to stop the bleeding. Ask your physician or teacher to show you how this is done.

Talk with the victim to help keep them calm. Do not attempt to move the victim—further injury could result.

Figure 2.11.e. Severed arteries spurt blood with pressure. Credit: Penn State Extension Ag Safety Team

Sometimes the best help for an injured victim is for you to seek more help.

Safety Activities

1. Conduct a farm survey to identify the locations of first aid kits. Are they complete? Have supplies been replaced?
2. Conduct a survey of all the people on a local farm to find out how many have been trained in first aid and CPR.
3. Complete a CPR course sponsored by a local agency, such as the American Heart Association or the American Red Cross.
4. If you are certified in CPR, remember to enroll in a refresher course.
5. Complete a lifeguard certification program.
6. Join the local Junior Volunteer Fire Program of your local VFD to learn skills in fire safety and rescue.
7. Produce a poster showing the steps needed to perform mouth-to-mouth resuscitation.
8. Many schools and shopping centers now have automated external defibrillators (AEDs) to use if someone has a heart attack. Learn more about these devices and how they work.

9. Conduct a training session on responding to an emergency, such as a tractor turnover, machinery entanglement, or grain bin entrapment. Make sure that all family members and employees understand what to do in an emergency.
10. Offer to set up a farm accident rescue program for the local VFD and EMS groups. Seek adult sponsorship to help you do this.
11. Learn about pressure points used to stop arterial bleeding. Post a drawing of the body's pressure points in the farm shop.
12. Post detailed directions to your farm next to your telephone or in the directory of your cell phone. The directions should begin at your local emergency medical service.
13. Organize a day on the farm where everyone can learn and practice how to shut off every engine/motor in the event of an emergency.

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Farm Family Emergency Response Program. Penn State College of Agricultural Sciences, Department of Agricultural and Biological Engineering.

First on the Scene. Ithaca, NY: Northeast Regional Engineering Services (NRAES), 1989.

Occupational Safety and Health Administration website, **www.osha.gov**.

3

Section Three
Agricultural Hazards

Mechanical Hazards

Learning Goals

- Identify the mechanical hazards associated with agricultural machinery
- Avoid mechanical hazards

Related Task Sheets

- 2.3: Reaction Time
- 2.8: Hazard Warning Signs
- 5.4: Making Power Take-Off (PTO) Connections
- 5.4.1: Using Power Take-Off (PTO) Implements

Introduction

Many hazards in agriculture are associated with mechanical equipment. Knowing every hazard of every machine is very difficult. For this reason, agricultural safety and health professionals group them in ways that help the operator recognize the different types of hazards regardless of the machine.

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

Your ability to recognize hazardous components is the first step in being safe.

Pinch, Wrap, and Shear Points

A **pinch point** hazard is formed when two machine parts move together and at least one of the parts moves in a circle. 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.

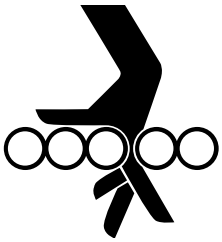


Figure 3.1.a. Pinch points can be found on most machines. Illustration credit: Association of Equipment Manufacturers; image credit: Michael Houtz, Penn State Extension.

Any type of rotating machine component can be considered a **wrap point**. The rotating components are often shafts, such as the PTO. Individuals can be caught in a wrap point by their loose clothing or long hair. Guards can protect the operator from wrap points. Attention to dress and care of long hair is also important.

A **shear point** occurs when the edges of two machine parts move across or close enough to each other to cut a relatively soft material. One

of the two objects can be stationary or moving, while the second is moving. Hedge trimmers are a good example of 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.

Crush, Pull-in, and Burn Points

Crush points are 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. The most common example of a crush point is formed 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 is decreasing. Do not permit another person to stand between the tractor and implement while hitching.

Pull-in points occur most often where crops are fed into harvesting machinery. Rotating parts that come in close contact with each other, such as feed rolls, often form pull-in points. Pull-in points can also be formed by moving components, such as feed chambers on square balers. To avoid being pulled into a machine, shut down the engine and disengage the PTO before making repairs or adjustments.

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 types of activities that may result in exposure to a burn point hazard. To avoid being burned, do not touch the engine or machine parts you are inspecting. Place your hand near the surface of the part to determine if heating has occurred.

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

Figure 3.1.b. A PTO stub and a master shield on a tractor. A PTO is a wrap point hazard that causes countless injuries and deaths each year. Credit: Penn State Extension Ag Safety Team

PTO Stub

- Transfers power from the tractor to the machine.
- Rotates at 540 RPM (9 times per second) or 1,000 RPM (16.6 times per second).
- Some tractors have a stub shaft guard that screws onto the PTO stub.

Master Shield

- Protects the operator from the PTO stub.
- Is often damaged or removed and never replaced.

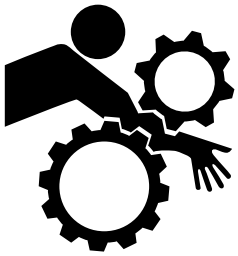


Figure 3.1.c. Pull-in points are found on harvesting machinery. Credit: Association of Equipment Manufacturers

Freewheeling Parts

Freewheeling parts continue to move after power to the machine has been turned off. These hazards exist because many machines require a large amount of rotational force to keep them running smoothly under irregular loading. Bringing this rotational force to a sudden stop is almost impossible. A baler is an example of the 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 3.1.d. 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. Notice that part of the PTO driveline is unguarded. Credit: Michael Houtz, Penn State Extension

Thrown Objects

These hazards occur as normal machine operations discharge materials into the surrounding environment. Rotating fan or knife blades that are used to cut, grind, or chop materials can throw small or large objects, such as glass, metal, rocks, sticks, or other vegetation. A common example of a thrown object hazard is the material that it 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.

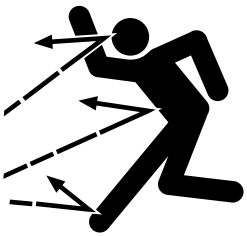


Figure 3.1.e. Mowers are a frequent source of thrown objects. Credit: Association of Equipment Manufacturers

Safety Activities

1. Draw a line from the mechanical hazard to the correct definition.

Pinch point	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.
Freewheeling part	A hazard formed when two machine parts move together and at least one of the parts moves in a circle.
Pull-in point	This type of hazard occurs when machine parts continue to move after the power to the machine is turned off.
Shear point	Any type of rotating machine component can be considered this type of hazard.
Crush point	These types of hazards occur when a machine discharges materials into its surrounding environment.
Stored energy	A hazard formed when the edges of two objects move across or close enough to each other to cut a relatively soft material.
Burn point	These hazards are caused by energy that is confined and then released.
Wrap point	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.
Thrown objects	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. Find an old and a new machine on your farm or at a local dealership and identify as many mechanical hazards as you can. Compare the two machines.

References

Association of Equipment Manufacturers Pictorial Database, **www.aem.org/safety-and-technical/safety/pictorial-database**.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Murphy, D. J. *Safety and Health for Production Agriculture*. St. Joseph, MI: ASAE, 1992.

Safety for Agricultural Equipment. ANSI/ASABE S318. St. Joseph, MI: American Society of Agricultural and Biological Engineers.

Noise Hazards and Hearing Protection

Is loud music or farm equipment causing you to lose your hearing?

Learning Goals

- Recognize when sound levels can become a threat to hearing
- Use correct hearing protection devices

Related Task Sheets

- 1.1: The Work Environment
- 2.7: Personal Dress

Introduction

Noise is defined as unwanted sound. It is one of the most pervasive occupational health problems, accounting for numerous worker compensation cases for hearing loss disability. Noise is a by-product of many agricultural processes. Exposure to high levels of noise causes hearing loss. The amount of damage to your hearing depends primarily on the intensity of the noise and the duration of the exposure. Noise can pose serious health risks to people. Hearing damage can occur with one loud noise over a relatively short duration or result from an exposure to less intense noises over an extended period of time.

This task sheet will examine the problem of noise hazards and how to protect your hearing.

What Is Noise?

The sound generated by machines or animals consists of pressure changes in the air that cause vibration or turbulence. These pressure changes produce sound waves that radiate outward from the source.

All sound, including noise, is measured in decibels. The unit of measurement is shown by the designation dB(A). A decibel meter is a tool that measures the dB level. The "A" represents the sound scale used for the measurement.

Not all sound levels are a hazard. Knowing typical sound levels for various sources of sounds helps us understand if the sound level is unsafe. Consider the following decibel level information.

Table 3.2.a. Decibel levels

dB(A) Level	Sound Source
15	A 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	Stereo with headphones set at mid-volume
120	Bad muffler or rock concert
140	Shotgun blast or jet engine

Sound levels that cause hearing loss begin at about 85 dB(A). Hearing loss occurs more quickly with louder noise. See Table 3.2.b for time exposure to various sound levels that can lead to hearing loss. OSHA standards consider sound measured at 85 decibels or higher as damaging to the eardrum and therefore a risk to hearing.

Figure 3.2.a. 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: Jeff Mathison

You don't adapt to loud noise; you lose your ability to hear loud noise.

Table 3.2.b. Permissible noise exposures.

Exposure time limits to sound levels decrease as the dB(A) level increases.

Duration per Day (hours)	Sound Level dB(A)
8	90
6	92
4	95
2	100
1	105
1/2	110
1/4	115

How Does Hearing Loss Occur?

Sound waves have pressure. High-frequency sound waves have greater pressure than lower-frequency sound waves. This pressure pushes on the ear drum.

Hearing loss occurs over a period of time. Deafness and loss of hearing usually occur with the high-frequency sounds and not the lower-frequency sounds.

Hearing is lost as 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.

Sound levels may be nearing the danger point for hearing loss if you notice any of the following:

- Ears ringing
- Noises in your head
- Your own speech sounds muffled
- You have to shout to be heard by someone working next to you

By the time you recognize any of these events, some hearing loss has already occurred.

Hearing loss accumulates over time (i.e., is chronic) and cannot be reversed. Use of a hearing aid may become necessary. Many older farmers have developed hearing problems over time. Hearing loss can also occur in younger people. With the knowledge gained from this task sheet, youth farm workers should avoid unnecessary hearing loss.

Protection of Hearing

Reduction of excessive noise is the first step to protecting your hearing. Hearing protection starts in the farm shop by keeping the exhaust and muffler system of the tractor in good repair. Machine parts that are not well lubricated or adjusted also cause loud noises. What farm tasks have you encountered that require hearing protection?

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. Compressor rooms may need to be soundproofed as well. Sound-insulating building materials can reduce noise levels. Where is the highest noise level likely to be found on your farm?

Types of Ear Protection

Commercially available hearing protection devices are recommended. There are two devices to use:

- Acoustical muffs
- Ear plugs

Ear protection devices are ranked by their noise reduction rating (NRR). An NRR31 rating signifies that noise will be reduced by as much as 31 decibels under ideal conditions. For example, in a 100-dB(A) work area, a device with a NRR of 31dB would reduce the effective sound level to 69dB. Be sure that the hearing-protection device reduces sound to a safe level. Typical ratings are shown below:

Device	dB NRR
Ear muffs	21–31
Ear plugs	26–33
Combined	add 3–5 dB

Ear Plugs

Ear plugs are made to fit into the ear opening. A proper snug, tight fit is critical 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, as ear infections can be spread in 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.

Figure 3.2.b. Ear plugs offer hearing protection, but not as much as full-ear-coverage protection devices. Illustration by Jeff Mathison

Cotton stuffed into the ears does not offer hearing protection!

Safety Activities

1. Obtain a decibel meter (available at electronics stores if your school or club does not have one) to measure and record the decibel levels of the following farming operations:
   a. Tractor being used to agitate liquid manure
   b. Tractor being used to operate ensilage blower
   c. Chainsaw in use
   d. Milk-cooling equipment compressor
2. Using a supply catalog, such as Gempler's or NASCO, make a list of the various ear protection devices, their NRR, and their cost.
3. Call a hearing protection salesperson and a hearing aid dealer to request hearing protection literature or invite them to make a presentation to your group, family, or coworkers.
4. Have a hearing test done as a baseline test to compare your hearing results on an annual basis.
5. Make arrangements with the school nurse or a volunteer nurse to conduct hearing tests for local farmers.
6. Use the tables in this task sheet to answer the following questions:
   a. What is the sound level at your high school dance or a rock concert?
   b. How long should you be exposed to that intensity of sound pressure level?

References

Occupational Safety and Health Administration website, **www.osha.gov**.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Respiratory Hazards

Coal miners can get "black lung" from breathing coal dust. Farmer workers can get "green lung."

Learning Goals

◊ Recognize respiratory hazards associated with agriculture

Related Task Sheets

◊ 1.1: The Work Environment
◊ 1.4: State Agricultural Safety and Health Resources
◊ 2.10: Personal Protective Equipment
◊ 2.11: First Aid and Rescue
◊ 3.9: Silos
◊ 3.10: Grain Bins
◊ 3.11: Manure Storage
◊ 3.12: Anhydrous Ammonia

Introduction

Farming can generate a lot of dust. Working with crops and livestock can expose you to other airborne contaminants. Microorganisms like fungi, bacteria, and molds can cause serious illnesses. The worker is often exposed to hazardous gases and vapors when working around machinery. Oxygen-deficient atmospheres associated with confined spaces present the risk of death. Continual exposure to breathing hazards creates long-term health problems. Farm workers can suffer from breathing difficulties, such as asthma, "farmer's lung," and organic dust toxicity syndrome.

This task sheet discusses the problem of respiratory hazards. Respiratory protection equipment and practices will be discussed in Task Sheet 3.3.1.

Dusts, Mists, and Fumes

Particulates are airborne particles of material that can be measured. Dusts, mists, and fumes make up a group of various-sized particles. They are measured in microns. A micron is 1/25,400 inch (50 micron-size particles are visible). Particle sizes over 5 microns are heavy enough to settle quickly without posing a respiration hazard. Finer materials are the major concern to lung health.

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. Many particle sizes are produced. Finely chopped crop particles can be inhaled into the lungs (respirable dust). As plant materials break down, molds and fungus are also inhaled.

Livestock production exposes the worker to dirt, dust, mites, fungus, and the dry, scaly skin found on or around the animal or bird or in its housing area. Antibiotics added to livestock feeds can also pose a respiration hazard.

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.

Mists

Liquid droplets suspended in the air represent mists as a respiration hazard. Paint sprays and cutting oil become airborne breathing hazards.

Fumes

Material that becomes airborne during welding (metal, welding rod, and flux) are examples of fumes. See the discussion of toxic gases and vapors below.

Figure 3.3.a. Welding produces fumes. Illustration by Jeff Mathison.

Gases and Vapors

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 their concentration and are trapped in the manure. 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. The gases are then released into the air.

With equipment breakdowns, unsuspecting farm workers, co-workers, and family members have entered the unventilated, low-oxygen-level, confined areas and been killed by suffocation. Often multiple fatalities have occurred while attempting a rescue.

Stay out of manure storage facilities! Manure gases can cause asphyxiation and eye and nose irritation, and methane can be explosive. See Task Sheet 3.11 for more details.

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 are often overcome with this gas. A few survive the exposure with lung damage, but many victims perish. See Task Sheet 3.9 for further discussion on silo safety.

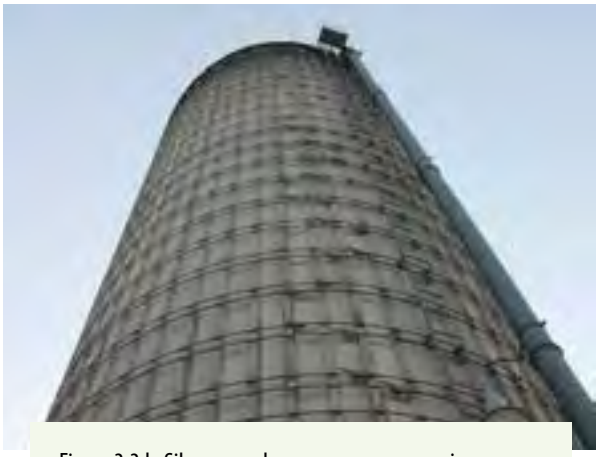


Figure 3.3.b. Silo gas can leave a person unconscious or dead. It is difficult to rescue a victim from inside of a farm silo. Credit: Penn State Extension Ag Safety Team

Farm Shop Gases

The farm shop exposes workers to respiratory hazards during jobs such as welding, painting, and engine repair. Ventilation is needed for each of these tasks. Check with the owner of the shop as to what safety procedures to follow to activate ventilation fans.

Welding

Ventilation is necessary during all welding processes. Fumes are produced as the metal melts and the welding rod and flux covering are burned. These fumes can irritate the nose and lungs. Galvanized metal emits zinc smoke fumes during welding. These fumes can be fatal

to inhale. Weld gases such as acetylene can be explosive in high concentrations. The arcing of a light switch can cause acetylene vapors to explode.

Figure 3.3.c. Dust from agricultural work can lead to eye and lung irritation. Credit National Children's Center for Rural and Agricultural Health and Safety

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! Be sure to ventilate the exhaust gases to the outside of the building or work with plenty of airflow into the building.

Figure 3.3.d. Internal-combustion engines produce carbon monoxide gas in the exhaust. Illustration by Jeff Mathison

Carbon monoxide vapors from engines can kill. This gas is colorless and odorless.

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 also possible. Read the labels on solvents and thinners to learn about ventilation requirements.

Lung Disease

Inhalation of dusts, mists, fumes, vapors, gases, and smoke causes irritation to the respiratory system. Repeated, prolonged exposure can cause more severe problems. Two of the problems, farmer's lung and organic dust toxicity syndrome, are described below.

Farmer's Lung

Farmer's lung is an allergic reaction caused by inhaling moldy hay, straw, and grain. When the lungs cannot remove the material, an allergy can develop. Repeated exposure further increases damage to lung tissue and the allergic reaction. Symptoms are similar to those of pneumonia.

Organic Dust Toxicity Syndrome

Caused by a reaction to inhaling molds from spoiling grain and forage, organic dust toxicity syndrome usually does not cause permanent lung damage. Symptoms can last for one to seven days and include cough, fever, chills, body aches, and fatigue.

Asthma

Asthma is a disease of the respiratory system. It is not known how people develop asthma. The small air tubes of the lungs tend to make more mucous than normal. When an asthma attack occurs, these air tubes swell, and the muscles around the air tubes tighten.

Asthma has several triggers, including:

- ◊ Allergies
- ◊ Infection (colds and bronchitis)
- ◊ Weather changes
- ◊ Smoke
- ◊ Physical exercise

Allergies such as exposure to dusts, mists, fumes, vapors, and gases irritate the lungs and can bring on an asthma attack. All of these irritants can be found in agriculture. Weather changes can lead to colds and bronchitis. Hot, humid weather and winter cold are factors in asthma.

Cigarette smoking or standing in the smoke of a burning fire also irritate the lungs. Sports activities and physical work can also trigger an asthma attack.

If you are an asthma sufferer, there are two recommendations.

1. Avoid those factors that trigger an asthma attack.
2. Follow your doctor's advice and prescription program.

Since repeated exposure to lung irritants reduces respiratory health, asthma can develop. Take the necessary precautions to protect your lungs from developing asthma and other respiratory problems.

Do you know someone who has asthma? They probably use an inhalant (medicine in an aerosol tube) to provide breathing relief. National statistics show an increase in the number of persons suffering from asthma.

Respiratory protection devices will be discussed in Task Sheet 3.3.1. Be sure to use the knowledge from this task sheet to select the proper respiratory protection for the materials with which you are working.

"When you can't breathe, nothing else matters." — American Lung Association

Safety Activities

1. Visit the American Lung Association website at **www.lungusa.org** to learn more about lung disease.
2. Invite a respiratory therapist to speak to you, your 4-H club, or FFA chapter about lung disease and its prevention.
3. Interview older farmers in the community about their experiences with "farmer's lung" and organic dust toxicity syndrome. Write an article to submit to an agricultural publication or newspaper in your state.
4. Interview people in your community who are welders. Ask them what they do to protect their lungs.
5. Go to **www.gemplers.com**, locate the respiratory protective devices for the uses listed in the table below, and fill out the remaining information in the table.

References

American Lung Association website, **www.lungusa.org**.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Device	Use	Price Range	NIOSH Rating
	Welding respirator		
	Dust/mist respirator		
	Nuisance odor respirator (livestock odors)		
	Full-face respirator		

Respiratory Protection

Try a different work practice, such as ventilation, to reduce breathing hazards. If you are still at risk, use a respirator.

Learning Goal

◊ Select the correct respiratory protection for use in specific agricultural work

Related Task Sheets

◊ 1.1: The Work Environment
◊ 1.2.4: Agricultural Worker Protection Standard
◊ 2.10: Personal Protective Equipment
◊ 3.3: Respiratory Hazards
◊ 3.5: Agricultural Pesticides
◊ 3.8: Confined Spaces
◊ 3.9: Silos
◊ 3.10: Grain Bins
◊ 3.11: Manure Storage
◊ 3.12: Anhydrous Ammonia

Introduction

Many people think farming means working in the clean, fresh air. However, farming has many respiratory (breathing) hazards. Some air may contain harmful dusts, chemicals, or gases or even insufficient oxygen.

This task sheet discusses respiratory protection devices to be used in agricultural work. Selection of a proper respirator is hazard specific. Many factors must be considered when selecting a respirator. Failure to use the correct device can be as dangerous as having no protection at all.

Breathing Hazards

The first step in selecting a respirator is to determine which hazard is present. Three categories of respiratory hazards can be found on the farm:

◊ Particulates (dusts, mists, fumes)
◊ Gases and vapors
◊ Oxygen-deficient atmospheres

Particulates

Particulates are airborne particles of sizes that can be measured. Dusts, mists, and fumes are the types of these various-sized particles. Dusts are the largest particles. Dusts may be dirt, but they can also be spores from moldy hay, silage, or grain. Mists are suspended liquid droplets held in the air from mixing, cleaning, and spraying operations. Fumes are particles of airborne solid evaporated metals, such as from welding tasks.

Gases and Vapors

Materials reacting chemically with the air produces gases and vapors. Gases are released from chemical reactions, such as manure decomposition, silage fermentation, and the exhaust of internal combustion engines. The gaseous products of these reactions 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, become vapors. These become airborne breathing hazards.

Oxygen-Deficient Atmospheres

The air we breathe is normally 21 percent oxygen. Some agricultural storage areas are oxygen free by either design or the chemical reaction going on inside of them, for example:

- Sealed silos are kept free of oxygen to keep certain bacteria from spoiling the silage.
- Controlled atmosphere storage of fruit and vegetables lowers the oxygen levels to maintain food quality and storage times.
- Manure storage, especially covered pits, become oxygen deficient due to manure decomposition depleting the oxygen supply.

Figure 3.3.1.a. 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: Penn State Extension Ag Safety Team

Hazardous atmospheres can be immediately dangerous to life and health.

Types of Respirators

There is no such thing as an all-purpose respirator. Specific respirators are used for specific contaminants or hazards. A disposable dust mask will not filter chemicals. A self-contained breathing apparatus is not needed to load hay onto a wagon. Respirators can be placed in two categories, air-purifying respirators and supplied-air respirators.

Air-purifying respirators are equipped with filters through which the user breathes. The respirator filters may either be disposable or replaced according to the material to be filtered. Filters should be replaced when your breathing becomes labored, the mask loses its shape or no longer fits your face, or you taste or smell the substance. A mechanical filter for particulates is not a replacement for a chemical filter.

Gas masks filter chemicals through a cartridge canister filter system. They have a full-face piece. Do not use the gas-mask-type respirator in an oxygen-limited area since they do not supply oxygen to the user.

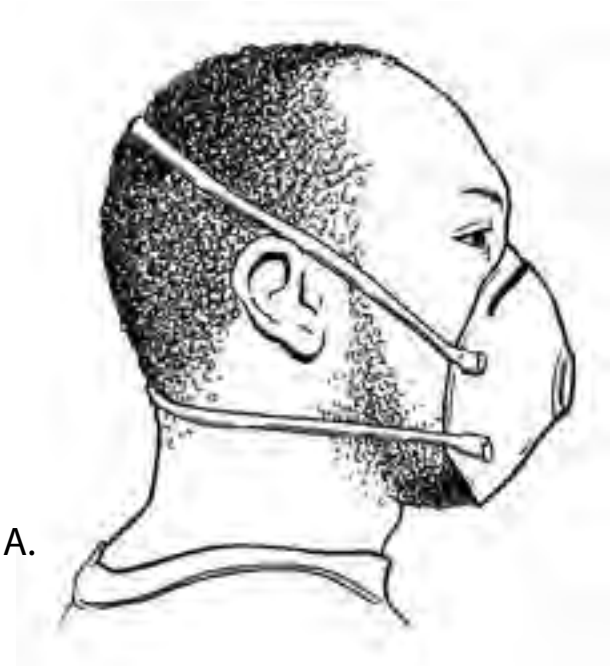
Powered-air purifying respirators have a motorized blower to force air through a filter to the wearer. A constant stream of air is placed over the user's head and face. They have the appearance of a hard hat with a face shield.

Air-supplying respirators bring an outside source of air to the wearer. These respirators are used in areas where the oxygen levels are so low that they are considered immediately dangerous to life or health. Air-supplying respirators are of two types, air-line respirator and self-contained breathing apparatus.

Air-line respirators supply air to a respirator face piece through a hose connected to an air pump or tank.

Self-contained breathing apparatus (SCBA) devices have a portable air tank that must be carried on the back, like those worn by scuba divers and firefighters.

Air-supplying respirators are expensive, and the user must learn and practice how to use them.



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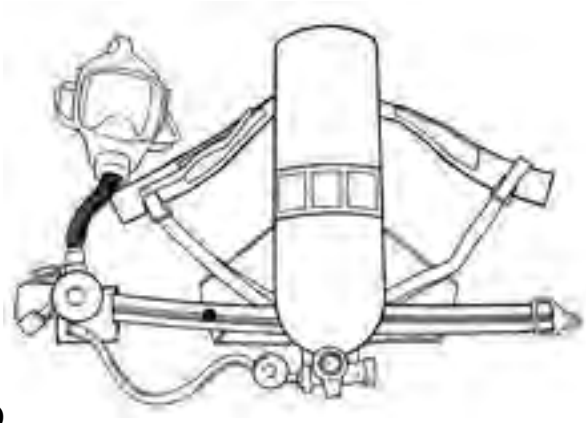

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Figure 3.3.1.b. Top Left (A) disposable toxic dust mask, Bottom Left (B) the chemical cartridge mask, Top Right (C) the powered air-purifying respirator, and Bottom Right (D) air-supplying respirators or self-contained breathing apparatus. Credit: Illustrations by Andy Mylin

Selecting a Respirator

Approved respiratory protection equipment should have NIOSH (National Institute for Occupational Safety and Health) symbol on the device. Letter and number designations can be found. Look for the designation to be sure that the respirator is approved.

Older labels will show the MSHA/ NIOSH TC# or approval number. For example, a TC-23C respirator is used for pesticides. Older respiratory protection devices may be found where you are employed.

Newer labels on respirators will show the NIOSH approval number and describe the new NIOSH-approved respirator. An example would be the NIOSH TC-23C dual-cartridge half mask with disposable filter used for pesticides and ammonia.

Under current standards, air-filtering masks or respirators are rated according to the filter's efficiency at reducing solid particles of dust, mists, and fumes. Respirators are rated as being 95, 99, and 99.97 percent effective at filtering dust particles.

Filters are also rated according to time-use limitations for protection against oil-based chemicals or pesticides in the atmosphere. The following designations are used:

- 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 is first

For example, a filter respirator may have a N99.97 NIOSH rating. This assures you that the filter offers 99.97 percent protection from exposure to particulates. In theory, there are no 100 percent filters. The work situation dictates the respirator to be used, not what happens to be hanging on the shop wall.

Figure 3.3.1.c. The chemical cartridge respirator mask has a replaceable filter to trap dust, chaff, and larger particles. These respirators do not supply oxygen. These respirators do not filter toxic dust and vapor materials. Illustration by Jeff Mathison

Figure 3.3.1.d. The nuisance dust mask is the simplest form of protection. These devices do not filter out small particles of dust that cause respiratory disease. You can identify a nuisance mask by its single strap. Illustration by Andy Mylin

Use and Care of a Respirator

Tight-fitting respirators must fit your face snugly to provide lung protection. A fit test must be performed to assess the protection of a tight-fitting respirator for each user.

User seal checks should be performed each time a respirator is put on. A properly fitted respirator will make an airtight seal around your mouth and nose but still allow you to breathe. Poorly fitted respirators provide little or no protection.

Reusable respirators must be properly maintained. The respirator must not expose you to harmful residues. Respirators must be cleaned after each use. Clean the respirator body with warm, soapy water and rinse thoroughly. Use a an appropriate disinfectant. Clean the straps as well.

Replaceable filters must be changed often following manufacturers' guidelines. Dirty filters will prevent you from breathing normally. Use disposable respirators once and then dispose of them. Any respirators that become damaged or soiled must be replaced.

Handkerchiefs are not respirators! They will not filter gases, fumes, or small particles.

Safety Activities

1. During a farm visit, list as many places as you can that are oxygen-limited structures or locations.
2. Are all silos oxygen limiting? Why or why not?
3. Visit a local orchard to find out more about controlled atmosphere storage of apples. Write a report.
4. Using a vendor's catalog such as Gempler's, Inc., locate the respiratory protective devices and make a table that includes the efficiency rating (95, 99, 99.97) and the respirator's rating for exposure to oils in the atmosphere (N, R, P) for each of the devices.
5. Match the recommended respirator type with the situation in which that respirator would be used:

A. Air-purifying filter mask with double straps	1. Oxygen-limited area, such as a manure pit
B. Chemical cartridge face shield and respirator	2. Nuisance dust areas, such as sweeping a shop
C. Self-contained breathing apparatus	3. Pesticide mixing and filling area

References

Centers for Disease Control and Prevention National Institute for Occupational Safety and Health website, **www.cdc.gov/niosh**.

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Murphy, Dennis J., and Cathleen M. LaCross. "Farm Respiratory Protection." Penn State Department of Agricultural and Biological Engineering.

Working with Livestock

Learning Goals

- Recognize hazards associated with caring for livestock
- Learn how to work safely with livestock

Related Task Sheets

- 2.1: Injuries Involving Youth
- 2.4: Age-Appropriate Tasks
- 2.7: Personal Dress

Introduction

Working with livestock is a major task that requires patience and training to keep you safe. Working with livestock can be pleasurable and rewarding but also hazardous. Observing a litter of piglets being born, assisting with the birth of a dairy calf, or training a young horse to lead by halter can be very satisfying.

Animals have their own patterns of behavior. Livestock can become frightened and react suddenly. Some livestock have strong maternal (mothering) instincts to protect their young, while breeding males may show territorial behaviors becoming aggressiveness toward handling. How well you understand animal behavior will be important to working safely with livestock.

This section discusses what you will need to know to work safely with livestock.

Livestock are linked to one in every five injuries on the farm.

Working with Livestock

Farm youth learn to work at an early age and 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 livestock project. Responsibility, confidence, and animal handling skills are gained by doing this work.

Statistics show us that working with livestock is also hazardous. Study these injury facts:

- According to 2014 national estimates, approximately 12,000 injuries to youth occurred on farms. Non-household youth on farms accounted for 37 percent of these injuries.
- Bureau of Labor statistics data between 2015 and 2016 show that there were 20 fatal occupational injury cases involving youth under the age of 16.
- In 2016, the animal production and aquaculture industry injury and illness rate was 174 per 10,000 full-time workers, while the national industry injury and illness rate was approximately 92 per 10,000 full-time workers.

Livestock hazards are also recognized as part of the Hazardous Occupations Order in Agriculture (AgHO). In these regulations, youth under age 16 are prohibited from working in a yard, pen, or stall with:

- Cows with newborn calves
- Bulls, boars, or stud horses kept for breeding purposes
- Sows with nursing pigs

Livestock jobs will vary in the level of injury risk presented to young workers. Caring for poultry, milking cows, and cleaning barns or equipment storage buildings may present low levels of injury risks depending on the age and experience of the youth. Adult supervision of children doing these tasks is recommended under the Agricultural Youth Work Guidelines.

If you are employed by a local farmer to work with livestock, the expectation is that you will be trained and supervised by that person to safely do that work.

Handling livestock exposes working youth to an increased risk of injury.

Figure 3.4.a. A cow with a newborn calf is usually protective of her offspring. Credit: Penn State Extension Ag Safety Team

Animal Behavior Facts

Animals have certain patterns of behavior that are instinctive and other behaviors that develop from habit. Cattle are "creatures of habit." Milking time finds cows lining up at the holding pen. The sound of feeding equipment being started is enough to bring animals to the feeder. Understanding animal behavior is the first step toward working safely with animals. Here are some animal behavior facts:

- Female species are maternal. They will try to protect their young from danger.
- Older male animals are more aggressive and unpredictable because of their hormones.
- Animals tend to group together (i.e., form a "herd") for safety. An isolated animal may act frightened and be difficult to handle.
- Animals are territorial. They may challenge an intruder that comes into their space.
- Animals tend to follow a leader when being moved. If no animal makes a move, the group tends not to move.
- Animals become acclimated to particular locations, sights, smells, and sounds. When moved to new and strange surroundings, livestock will react tentatively.
- Animals have a zone of comfort within which they will behave normally. Intrusion into that space will cause the animals to move to re-establish their comfort zone.
- Animals have poor depth perception and cannot see behind them. They will turn to keep you within their sight.

As an example of cows being creatures of habit, Roy's mother thought it was cute to teach the feeder calf to butt her hand with its head. When the FFA steer project weighed 1,200 pounds, the animal still liked to butt his head—but that wasn't fun anymore.

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 ideas are used with calm movement and the least amount of confusing noise.

Just like people, animals have personal space. The size of that space depends on the animal's tameness and excitement level, and the angle at which you approach the animal. If you move into the animal's flight zone, the animal will turn to move away from you. If you move outside the flight zone, the animal will turn to look at you. If the animal feels trapped in a corner and has limited vision, the animal will kick to warn you to stay away. 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 get kicked.

The animal will move according to your position at its point of balance. The point of balance is the animal's shoulder. All species of animals will move forward if the person is behind the point of balance. All animals will back up or turn away if the person is in front of the point of balance.

Using the point of balance works for moving larger groups of animals as well. Use this knowledge 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. The leader will move in front and to the back of the point of balance to move their animal easily.

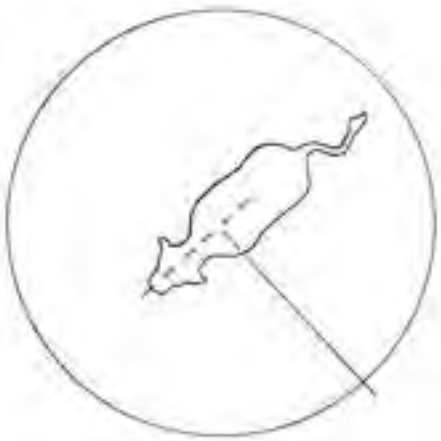

Figure 3.4.b. Flight zone. Credit: Penn State Extension Ag Safety Team

Precautions to Take

Livestock chores are not hazardous if the animal's behavior is understood. There are precautions to follow to ensure the work is a pleasant experience that is free of injury. Plan to use the following safety measures when working with livestock:

- ◊ Plan an escape route. 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 appropriate handling faculties, such as squeeze chutes, to hold animals securely for veterinary procedures.
- ◊ Approach livestock so that they can see you coming.
- ◊ Move cattle in well-lit areas, not shadowy places.
- ◊ Avoid quick movements and loud noises.
- ◊ Be patient.
- ◊ Keep animal-handling facilities in good repair, with no sharp projections or edges.
- ◊ Ask for help to move or work with an animal if the animal is excited or nervous.
- ◊ If the animal becomes nervous and agitated, pause and wait for the animal to calm down before attempting to work with the animal again.

When working with animals, give yourself a route of escape. Do not corner the animal!

Safety Activities

1. Use a basketball and a tennis ball to represent an animal and a person, respectively. Roll the tennis ball against the basketball to determine if the larger ball can be moved easily. Then roll the basketball against the tennis ball to determine if the tennis ball can stop the basketball. What did you observe?
2. Most animals are territorial. What does this mean? Make a list of incidences you have observed where an animal exhibited territorial habits and write down how they acted/reacted.
3. Use the Internet to locate your state's land-grant university and/or college of agriculture website. Search this site for any information you can find on how to construct animal-handling facilities for moving animals (chutes) and holding animals (squeezes). Make a sketch of the plans with dimensions.
4. Inspect a farm's facilities for handling livestock. How many pass-through gates are available?
5. Ask a friend who has a halter-broke animal to exhibit at the county fair. Ask your friend to show you how easily an animal will move backward or forward based on a person's slight movement in front of or behind the point of balance.
6. Practice moving a group of animals slowly and quietly by using knowledge of the flight zone and point of balance.
7. Make a poster of the flight zone of a beef animal, dairy cow, hog, or horse to show others how to move safely around animals.
8. Inspect all animal pens and alleyways where you will work for sharp obstructions (nails, sheet metal, etc.), broken boards, and damaged gates. Report your findings to the owner. Suggest to the owner that they be repaired. Perhaps this is something you can do as an employee of that farm.

References

"Census of Fatal Occupational Injuries (2011 Forward)." Bureau of Labor Statistics, **data.bls.gov/PDQWeb/cs**.

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"Livestock Handing." National Education Center for Agricultural Safety, **web.nicc.edu/Marketing/NECAS/pdfs/Livestock_handling_updated.pdf**.

"Nonfatal Cases Involving Days away from Work: Selected Characteristics (2011 Forward)." Bureau of Labor Statistics, **data.bls.gov/PDQWeb/cs**.

National Children's Center for Rural and Agricultural Health and Safety's "Cultivate Safety: Work Guidelines" website, **www.cultivatesafety.org/work**.

Agricultural Pesticides

Learning Goals

- Understand that 14- and 15-year-old workers cannot use some agricultural chemicals
- Understand the warning signs and symbols used on agricultural pesticides

Related Task Sheets

- 1.2.1: Hazardous Occupations Order in Agriculture
- 1.2.4: Agricultural Worker Protection Standards
- 2.7: Personal Dress
- 2.10: Personal Protective Equipment
- 4.6.2: Lead Acid Batteries

Introduction

Modern farming relies on many chemicals to produce and preserve an abundance of high-quality food. Fertilizers, pesticides, cleaners and sanitizers, crop preservatives, fuels, and solvents are chemicals.

Certain pesticides used on farms pose a health hazard. Youth younger than age 18 who are not immediate family members employed by agricultural establishments are prohibited from using certain agricultural pesticides.

This task sheet discusses agricultural pesticides from a youth information standpoint. Older workers can be called upon to handle and apply restricted-use pesticides. If under 18 years old and asked to work with restricted-use (Category I and II) agricultural pesticides, tell your employer that you are under age 18 and prohibited by law from doing so. See Task Sheet 1.2.2.

Exposure to ag chemicals can lead to a variety of symptoms, including paralysis and/or death.

Pesticide Use Restrictions

At age 15, you have been hired to work at your neighbor's farm. You have passed the safe tractor and machinery certification program. On your first day of work, a fellow farm employee has assigned you to rinse pesticide containers for return to the dealer and to burn pesticide bags. This may sound like a safe job for you to do, but is the job actually safe?

Although Hazardous Occupations Order in Agriculture regulations cover more than just tractor and machinery operation activities, Worker Protection Standard (WPS) regulations would be followed in this case.

WPS restricts the age of pesticide handlers and early entry workers to 18 years or older. This would prohibit you from handling or applying (including cleaning or decontaminating equipment, disposing of or returning empty containers, or serving as a flagman for aircraft) agricultural chemicals classified as toxicity Category I (identified by the word "DANGER/ Danger-Poison" and the "skull and crossbones" on the label) or Category II (identified by the

word "WARNING" on the label) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

Categories of chemical toxicity and their signal words are explained later in this task sheet.

Effects of Pesticides on People

Agricultural pesticides may come in dust form, granular particles, liquid concentrates, or solutions. They appear innocent and safe, but they are complex chemical compounds with very serious effects on humans.

Exposure to pesticides produces a variety of symptoms, including headache, nausea, stomach cramps, diarrhea, chills, fever, fainting, and possibly paralysis and/or death. Sometimes people mistake pesticide poisoning for what they call the "summer flu."

Learn the signal words used on pesticide containers.

Signal Words and Categories

Pesticides fall into one of four toxicity categories. Pesticides in Categories I, II, and III must display signal words. These industry-standard words tell the user the product's acute (short-term) toxicity. Toxicity refers to the degree to which a substance can harm humans or animals. Signal words found on pesticide labels are:

- ◊ Danger-Poison (skull and crossbones included)
- ◊ Danger
- ◊ Warning
- ◊ Caution

Danger-Poison

Products in toxicity Category I show the "Danger-Poison" signal word. These products are highly toxic if ingested, absorbed through the skin, or inhaled. A skull and crossbones must appear in immediate proximity to the word "Poison." These chemicals may be corrosive (can burn) to the eyes and skin and lungs. The oral LD50 (lethal dose) for this category is considered less than or equal to 50 milligrams (mg) of chemical per kilogram of body weight. These chemicals are "restricted-use" materials due to increased risk to human health and/or the environment. They require certification to purchase and use.

Toxic means deadly.

Figure 3.5.a. The most toxic of chemicals will display the signal words "Danger-Poison," along with the skull and crossbones. Peligro is Spanish for danger.

Danger

Products in toxicity Category I can cause severe skin irritation and eye damage. These products are highly toxic by at least one route of exposure.

Warning

Products in toxicity Category II use the signal word "Warning." Eye irritations could last one week or longer as a result of exposure to these products. Severe skin irritations may last 72 hours or longer. An oral LD50 for this category is greater than 50 mg up to 500 mg of chemical per kilogram of body weight. These products are restricted-use pesticides.

Caution

Product labels using the signal word "Caution" are in either toxicity Category III or IV. Mild skin and eye irritation results from exposure to these chemicals. Pesticides sold over the counter to consumers use the signal word "Caution."

Ag Pesticide Exposure

Exposure to pesticides over time can be harmful. Exposure can be minimized by wearing personal protective equipment (PPE). Pesticide labels provide specific requirements for the PPE that will give maximum protection and reduce pesticide exposure. PPE use does not make it legal for youth younger than age 16 to handle or apply pesticides—the handling and application of pesticides is prohibited for youth younger than age 16 employed on family farms.

Chemical exposure can occur in four ways:

- ◊ Oral (mouth)
- ◊ Dermal (skin)
- ◊ Inhalation (lungs)
- ◊ Ocular (eye)

Oral (Mouth) Ingestion

Pesticides can contaminate the hands through the handling of the container. Small amounts of the chemical may end up on cigarettes, chewing tobacco, food, or drinks touched by contaminated hands. Ingestion of pesticides through food is a common means of exposure. Hands could also be an oral source of exposure.

Dermal (Skin) Exposure

Pesticides may be taken in through the skin. Even the act of urinating with pesticide-covered hands causes pesticide exposure. Some people mistakenly think that tough, calloused hands reduce the entry of the pesticides through the skin. Even by wiping the sweaty forehead or the back of the neck, dermal exposure occurs to those more sensitive tissues. Touching treated surfaces or handling empty containers may cause dermal exposure. Even walking through a recently treated field can risk dermal exposure.

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 provides the fastest route of exposure into the bloodstream.

Ocular (Eye) Exposure

Splashing of liquid chemicals and dust from granular pesticides during handling, mixing, or rinsing of containers is a source of risk to the eyes.

Improper handling of agricultural pesticides can result in the production of toxic fumes and vapors.

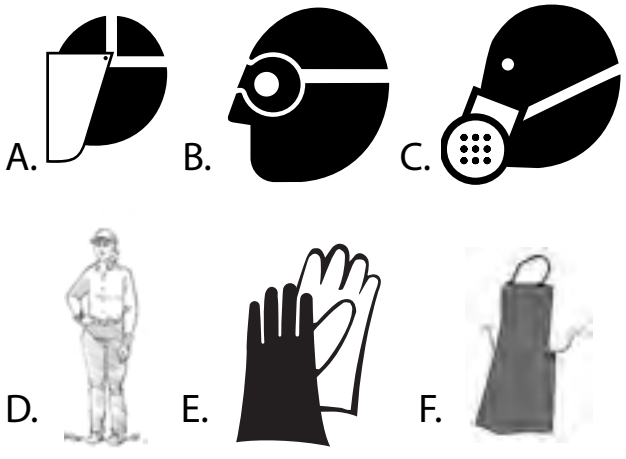

Figure 3.5.b. (A) face shields and/or (B) goggles, (C) respirators, (D) long sleeves and pants, (E) chemical-resistant gloves and (F) aprons should be used when handling pesticides, strong detergents, sanitizing chemicals, degreasers, and battery acid. Credit for (A), (B), (C), (E): AEM Pictorial Database. Credit for (D) and (F): Jeff Mathison

Safety Activities

1. Perform an agricultural chemical inspection on a farm with the owner's permission. Make a list of all the chemicals that you find and the signal words that are included on their labels. Do not handle containers with materials spilled over the outside of them.
2. Solve this crossword puzzle using the words inhalation, face shield, ingestion, caution, warning, rubber gloves, dermal, ocular.

References

Association of Equipment Manufacturers Pictorial Database, **www.aem.org/safety-and-technical/safety/pictorial-database**.

Pennsylvania Pesticide Applicators Certification Core Manual. University Park, Penn State Extension, 2008.

Safety Management for Landscapers, Grounds-Care Businesses and Golf Courses. John Deere Publishing, 2001.

Electrical Hazards

Learning Goals

- Understand electrical hazards
- Safely work with electrical equipment used in agriculture

Related Task Sheets

- 2.6: Housekeeping
- 3.7: Fire Safety

Introduction

Farms use electricity to power many tools and equipment. Jobs that were once labor intensive are now done 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.

Each year numerous farm workers are electrocuted in the United States. Being safe with electricity is a work skill that must be mastered.

This task sheet discusses the hazards posed by electricity. Beginning-level farm workers will use many of the systems mentioned in this task sheet.

Electricity can kill. Keep alert!

Electrical Hazards

Using electrical-powered equipment and tools can lead to several hazards, including electric shock, heat, and fire.

Electric Shock Hazard

Electric shock is a sudden violent response to electrical current flowing through a person's body. Relatively very small amounts of current are needed to cause injury. Primary electrical injuries result in tissue damage caused by an electrical current or voltage. Secondary injuries, such as falls, are commonly associated with electrical shock. Electrocution is death caused by electrical shock.

The human body's response will vary depending on the amount of current flowing through it. Current-related injuries result from tissues being heated (burns) and muscles and nerves being stimulated (loss of muscular control). The heart muscles will lock up if an electrical current passes through the heart when all the heart valves are closed (rest phase). It only takes 20 milliamperes to cause death by respiratory arrest. As a frame of reference, common circuit breakers are rated for 20 amperes (1 ampere = 1,000 milliamperes).

Figure 3.6.a. Electrical shock hazard symbol. Credit: AEM Pictorial Database

Heat and Fire

Electricity can be the source of heat to ignite flammable materials. Current flow in a conductor produces heat because of the conductor's resistance to the flow of electricity. Increased heat in electrical conductors can be expected when:

- The wire size is too small to carry the current (e.g., trying to run an electric motor on a lamp cord)
- The electrical load is too great (e.g., operating a hair dryer, curling iron, and toaster on the same circuit)
- The electrical load is too far away from the electrical source (e.g., a half electric drill motor operated at the end of a 100-foot extension cord)
- The electrical connections are loose, and increased resistance develops

There is a high risk of electrical fires in agricultural structures like barns due to conductor exposure to environmental conditions and inadequate wiring practices.

Electrical Devices You May Use

Work assignments on the farm may require use of electrical appliances and tools. The following describes the electrical equipment you may be called on to use. **Note:** Hiring a qualified electrician will be necessary to work with the electrical system beyond what is described here.

Distribution Panel

The circuit breaker or fuse box contains many circuits. This is the location of circuit breaker devices to stop the current flow to an electrical circuit. You may be assigned to go to the distribution panel (sometimes called circuit breaker panel or fuse box) to turn a circuit on or off.

Circuit Breakers and Fuses

Found in the distribution panel, these devices protect the wires of the circuit from overheating. Overloads cause fuses to "blow" and circuit breakers to "trip" to electrical flow. Three common protective devices are:

- Fuses
- Circuit breakers
- Ground fault circuit interrupters

Fuses

Fuses are either screw in or cartridge type. A metal strip melts when the circuit is overloaded and interrupts the circuit. The fuse must be replaced. Shut off the "main" power switch before changing fuses.

Circuit Breakers

Circuit breakers look like switches. When a bimetal (two different metals) strip is heated from electrical overload, the metal becomes distorted in shape and causes the circuit breaker to cut out. The overload problem must be corrected, and the switch returned to the on position.

Ground Fault Circuit Interrupters

Ground fault circuit interrupters (GFCIs) can look like an electrical outlet or a circuit breaker. These GFCI devices break the circuit in microseconds when a difference in current is sensed. They 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 different from regular outlets.

If fuses, circuit breakers, and GFCI devices are constantly blowing, ask your employer to check the situation before you continue.

Switches and Receptacles

Switches energize circuits. Receptacles connect the appliance to the circuit. Careless use can damage the receptacle and appliance. If you are assigned to a job where the electrical switch and/ or receptacle is damaged, ask the employer to make the repairs.

Underwriters Laboratories

Electrical components must meet the Underwriters Laboratories (UL) standards. Look for the UL symbol to be sure the device has approved safety construction.

Overhead Power Lines

Many overhead power lines do not have insulating covers. They normally carry higher voltage than building circuits. The person (or the machine the person is moving or operating) becomes part of the electrical distribution grid. Contact with these wires can lead to death. Many deaths on farms are due to contact with overhead wires.

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.

To prevent this hazard situation:

- ◊ Lower augers and elevators for transport.
- ◊ Look up and take notice of overhead power lines.
- ◊ Use a "spotter" while moving equipment under utility wires.

Figure 3.6.b Lower the hay elevator or grain auger to avoid contact with overhead power lines. Illustration by Jeff Mathison

Recognizing Electrical Hazards

You do not have to be an electrician to be safe around electrical circuits. Use the ideas below to be a valuable and safe employee.

Circuit Breakers and Fuses

If circuits are constantly breaking (shutting off), the circuit is overloaded. Tell your employer. Do not put foil or a copper penny in the fuse socket to eliminate the fuse. Even larger capacity fuses add to the dangers. Using a jumper wire to bypass the circuit breaker is not a good idea.

Grounding

Three-prong appliance plugs ensure the circuit is grounded. Do not cut off the third prong (round prong) to make the plug fit; a two-prong adapter with ground strap should be used.

Lock-outs

Distribution panels or fuse boxes can be fitted with a lock. Lock these boxes to prevent children and visitors from contacting the wiring inside of them. When working with an electrical circuit that is out of sight of the fuse box, lock the fuse box or controller so that another person does not accidentally energize the circuit while you are working.

Hostile Farm Conditions

Dust, moisture, corrosive materials, gases (manure), and physical damage are hard on electrical equipment. Report broken or damaged electrical equipment to your employer.

Figure 3.6.c. Improper electrical wiring methods and materials placed into a hostile farm environment can lead to fires and electrocution of people and livestock. Credit: Penn State Extension Ag Safety Team

Extension Cords

Extension cords are often 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 may be buried. For public utility locations, call before digging. Check **www.digsafe.com**, a national directory, for the phone number in your state. The service is free.

Machinery contact with overhead wires causes many farm fatalities due to electrocution.

Safety Activities

1. With the permission of the farmer/owner, conduct an electrical safety survey of a farm in your area. Use the table below to complete the survey.

Area to Inspect	How Many Found	Where Found
A. Lock-out devices with locks attached		
B. Electric boxes or controls damaged by hostile farm conditions		
C. Low-hanging power lines		

2. Research the topic "stray voltage" to learn how a dairy cow can experience being electrically shocked in a barn setting.
3. Find out why a toaster wire heats up to toast our bread and an electric iron heats up to iron the wrinkles from our clothes. For help, go to **www.howstuffworks.com**.
4. Research the topic "ground fault circuit interrupter." How does this device work and where should it be used?

References

Association of Equipment Manufacturers Pictorial Database, **www.aem.org/safety-and-technical/safety/pictorial-database**.

"Controlling Electrical Hazards." Occupational Safety and Health Administration, **www.osha.gov/Publications/3075.html**.

"Electrocution." Occupational Safety and Health Administration Youth in Agriculture, **www.osha.gov/SLTC/youth/agriculture/electrocution.html**.

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Fire Safety

Learning Goals

- Understand the three factors that support a fire
- Understand the three classes of fire

Related Task Sheets

- 2.6: Housekeeping
- 3.5: Agricultural Pesticides
- 3.6: Electrical Hazards
- 3.7.1: Fire Prevention and Control
- 3.7.2: Hay Storage Fires

Introduction

Fires may occur in homes, machinery shops, barns, silos, and even around farm machinery and automotive vehicles. Grease may catch fire in the kitchen or shop. Flammable materials may ignite when welding or metal cutting is done nearby. Dust and crop debris can be ignited in or on machinery. Spontaneous combustion may 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 should be avoided. You must understand what causes fires, fire prevention, and fire extinguishing methods. Practice prevention and plan for fire incidents. Having a plan will help keep you focused and in control of the situation.

This task sheet provides information on fires in agricultural settings.

Definitions

Auto-ignition: to spontaneously ignite (catch fire) without an external spark or flame (e.g., in situations where flammable materials are stored near an open flame or where heat can build up).

Combustible: able to catch fire and burn easily.

Flammable: synonym for "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.

Kindling point/ignition point: lowest temperature at which a solid material will ignite and begin to burn when brought near a source of heat.

Spontaneous combustion: phenomenon in which a material unexpectedly bursts into flames without apparent cause (see Task Sheet 3.7.2).

Vapors: gas form of substances that are normally in the solid or liquid form.

Volatility: tendency of a liquid to vaporize or evaporate into the air (e.g., gasoline is volatile).

The Fire Triangle

Three things are necessary for a fire to start and continue to burn: fuel, heat, and oxygen. Fuels can be a variety of materials. Heat sources can be electrical, open flame, sparks, and chemical reactions. Oxygen is part of the chemistry that supports a fire. Without any one of these factors, a fire cannot exist.

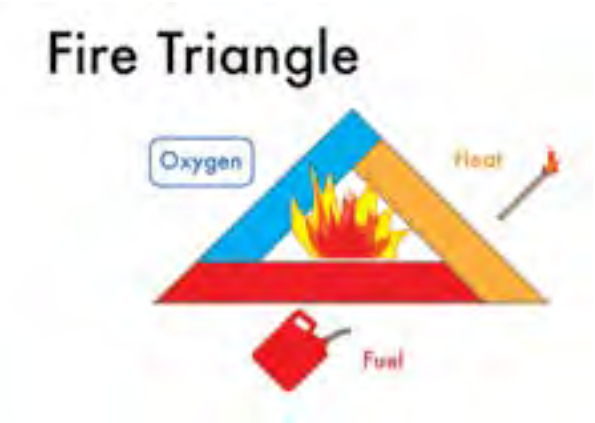


Figure 3.7.a The fire triangle. Heat, fuel, and oxygen (air) must be available to support a fire. Illustration by Jeff Mathison

Three things are needed for a fire to exist: fuel, heat, and air.

Fire Classification

Fires are classified according to the fuel that burns. A letter designation system is used. Categories of fire common to agriculture and rural residences are Class A, B, and C.

- Class A fires involve wood, paper, rubbish, plastic, and crop materials.
- Class B fires involve burnable liquids, like grease, oil, and fuels.
- Class C fires involve electrical sources, such as motors, wiring, switches, and connections.

Fires are classified by letters that represent the fuel involved.

Class A Fires

Class A fires involve wood, paper, rubbish, plastic, and crop materials. These fuels have a "kindling point" or "ignition point." The kindling point is the lowest temperature at which the substance will ignite and begin to burn. For example, small pieces of wood burn more quickly than a large fire log. A fire in a home fireplace must be started with small pieces of kindling wood. You cannot start a campfire with the largest fire log because it has a high kindling point and would need much more heat than a match could provide.

The kindling points of Class A materials vary with the material, its thickness, and moisture content. Dust has a low kindling point. Dust from Class A materials can also burn quickly and violently. At high levels of concentration, dust can even explode. Sparks from electric motors can cause the fire. Dust explosion provides proof that smaller particles burn more quickly than larger particles.

Electrical equipment also can create sparks during its operation. Class A and B fires can be ignited by electrical overloads and sparking.

Class B Fires

Class B fires involve liquid materials that have the ability to produce vapors. These vapors can burn. When liquids give off enough vapors to burn, the fuel has a "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 (i.e., have a low flash point). Diesel fuel and paint thinners produce fewer vapors

(i.e., have a high flash point). Diesel fuel and paint thinners burn slowly when an open flame is placed directly near the fuel surface. Acetylene gas for welding and cutting is the product of a chemical reaction involving liquid elements producing gas. These vapors burn explosively.

Because of the volatility of Class B fuels, auto-ignition may occur near open flames or in storage areas where heat can build up.

Heavier than Air or Lighter than Air?

Some fuel vapors are heavier than air and settle to the lowest point nearby. Gasoline and diesel fuel are examples. Gasoline (the most volatile 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 is less volatile, with the vapors being held near the surface of the fuel itself.

Precaution: When working on a vehicle inside a shop or garage, do not permit gasoline to be spilled. Vapors may travel across the floor and be ignited by hot water tank pilot lights, welding sparks, and the sparks from a dropped, broken portable shop light.

Heavier than Water or Lighter than Water?

Class B liquid material fuels have weight or density. Some fuels may float on water, while others may 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 could be ignited and burned on top of the water.

Precaution: A major 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 of gaseous products gather in an enclosed space, they can be ignited by simply turning on a light switch. 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 the light switch is turned on. Acetylene tanks should be drained properly. Ask your employer about this hazard.

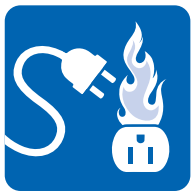
Hint: Smell the air in the acetylene storage area before flipping the light switch to turn on the lights. If it is safe, you should not be able to smell acetylene vapors. You can prevent an explosion by smelling the air first!

Figure 3.7.b. Vapors are produced by cleaning solvents, gas, and paints. When these vapors pass off into the atmosphere, they are called volatile. Illustration by Jeff Mathison

Vapors and dust can be explosive.

Figure 3.7.c. Dusty, dirty conditions in agriculture contribute to increased fire hazards. What materials in this picture are considered Class A fuel sources? Credit: Penn State Extension Ag Safety Team

Class C Fires



Class C fires involve electricity. These fires have electricity as the source of both fuel and heat. Motors, wiring, switches, and controls can overheat, which is usually caused by an electrical overload. Electricity generates heat. Electrical parts can catch fire. Nearby flammable objects can be ignited. Increased heat in electrical wiring can be expected when:

- The wire size is too small (e.g., trying to run an electric motor on a lamp cord).
- The electrical load is too great (e.g., operating a hair dryer, curling iron, and toaster on the same circuit).
- The electrical load is too far away from the electrical source (e.g., a ½-horsepower electric drill motor operated at the end of a 100-foot extension cord).
- The electrical connections are loose.
- The electrical equipment is malfunctioning.

Figure 3.7.d. Welding sparks from electric arc welders and oxyacetylene gas welding equipment can create the spark that ignites nearby flammable materials or vapors. Illustration by Jeff Mathison

Safety Activities

1. Review the fire safety lessons you learned in elementary school. What does "Stop, Drop, and Roll" mean?
2. Learn about the correct method of using a fire blanket. If you had to help someone who had caught on fire, would you know what to do?
3. Conduct a survey of a local farm to locate the placement, condition, and number of fire extinguishers on the tractors and other machinery and in the buildings. Make a report of your findings by making a chart or map.
4. Join a local fire department as a junior volunteer.
5. Use the Internet to learn more about fire hazards and fire safety on farms. Type the phrase "fire safety" into any search engine.
6. In a safe location, secure a lighted candle so that it does not fall over. Lightly sprinkle fine metal shavings over the flame. Do the metal filings burn? Hint: The metal filings can be secured from a science teacher or by sweeping the area around a shop grinder. Do not use oily filings.
7. Can you tell what class fires D and K are? If not, time for a little research.

Credit for Class A, B, C, D, and K fire images: Andy Mylin

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Farm and Ranch Safety Management. John Deere Publishing, 2009.

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"Silo Fires." Penn State Extension, **extension.psu.edu/silo-fires**.

HOSTA Task Sheet 3.7.1

Fire Prevention and Control

Learning Goals

- Able to prevent fires
- Select the proper fire extinguisher to use in a specific fire situation

Related Task Sheets

- 2.6: Housekeeping
- 3.5: Agricultural Pesticides
- 3.6: Electrical Hazards
- 3.7: Fire Safety

Introduction

An understanding of fires helps with prevention and control. While fires are often unexpected, they are usually predictable in their behavior. People, however, are unpredictable in their behavior with fire. People often panic when faced with a fire situation.

This task sheet discusses fire prevention and control as a means of helping the young agricultural worker deal calmly with unexpected fires. Task Sheet 3.7 describes the science of fire in detail.

People tend to panic in a fire. Such behavior causes further panic.

Fire Prevention

A majority of fires can be prevented. Remember the fire triangle? Fuel, air, and heat must react together for a fire to exist. 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 will lead to a sound fire prevention program. Work site analysis, maintenance, housekeeping, and fire prevention and control training are proven methods of reducing the risk of fire.

Work Site Analysis

Fire hazards should be surveyed at each farm. Combustible 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 that cause of fire. Good housekeeping helps prevent fires. Clean up oil-soaked rags to reduce the risk of sparks igniting the cloths.

Fire Prevention and Control Training

Everyone working on the farm must be a partner in the prevention and control of fires. All employees should have a job description that includes:

◊ Regular fire hazard inspection
◊ Training in fire extinguisher use
◊ Good housekeeping procedures

Being knowledgeable about fire prevention and control procedures is everyone's responsibility.

Figure 3.7.1.a. Poor housekeeping contributes to potential fire hazards in farm shops and other structures. What class of fire might exist in the area that this picture represents? Credit: Penn State Extension Ag Safety Team

Fire Extinguishers

Fire extinguishers are identified by a pictorial attached to the extinguisher body showing the type of fire for which they should be used. In an emergency, these standard graphics give us instant information about the extinguisher.

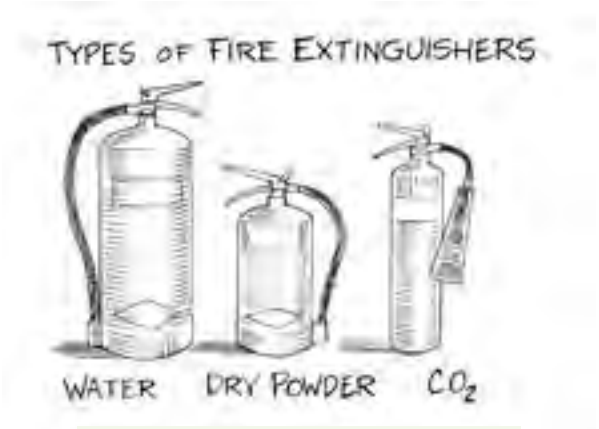

Figure 3.7.1.b. Fire extinguishers must be used on the class of fire for which they are rated. Illustration by Jeff Mathison

Water-Type Extinguishers

Water-type extinguishers contain water under pressure. The water cools the fire to extinguish it. Water-type extinguishers are made of stainless steel and have a pressure gauge and long hose.

Use water-type extinguishers for Class A fires only. Water spreads grease fires and conducts electricity. Water applied to an electrical fire will conduct the electrical charge back to the user, resulting in electrocution.

Chemical Extinguishers

Chemical extinguishers contain a dry chemical powder. The dry chemical powder extinguisher is identified by its short, thick, red-colored container with a bright metal nozzle next to the pressure gauge. 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.

Dry chemical powder extinguishers can be used on Class A, B, and C fires. The 10-pound dry chemical extinguisher is recommended for use.

Another chemical extinguisher is the Halon extinguisher. These extinguishers contain a gas that interrupts the chemical reaction that takes place when fuels burn. This type of extinguisher is often used to protect valuable electrical equipment since they leave no residue to clean up.

Carbon Dioxide Extinguishers

Carbon dioxide extinguishers contain CO_2 (carbon dioxide) gas. CO_2 extinguishers are identified by a red container with a larger, black, funnel-shaped nozzle that can pivot near the pressure gauge area. The pressurized CO_2 gas contacts the air and forms dry ice. The fire is cooled by the dry ice. This extinguisher can be used on small Class B and C fires. 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 that it can burn the skin if a person touches it.

Fire extinguishers should be inspected regularly for leakage.

Using a Fire Extinguisher

Do not treat fire extinguishers like toys. Squeezing the trigger to discharge the fire extinguisher just once will be enough to drain the pressure. When the extinguisher is actually needed, it will not function properly.

To use a portable fire extinguisher, follow the steps called PASS:

- ◊ **P**ull the pin.
- ◊ **A**im at the base of the fire.
- ◊ **S**queeze the trigger.
- ◊ **S**weep 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, which will be wasted if the user aims above the flame. Second, the fire extinguisher material will form a barrier above the fire. The flames can roll up under the barrier toward you.

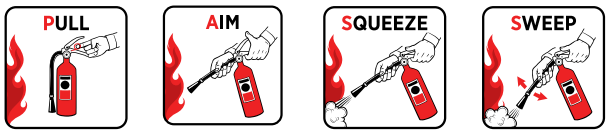

Figure 3.7.1.c. Proper way to use a fire extinguisher. Review the PASS acronym as you look at these pictures. Credit: Andy Mylin

Figure 3.7.1.d. All tractors should have a dry, chemical-type fire extinguisher on board. Today's high-priced tractors and equipment should be fire control ready. Credit: Penn State Extension Ag Safety Team

Fire Preparedness

Being prepared to control a fire is different from preventing fire hazards. A number of steps need to be taken to prepare for a fire emergency. Consider starting these practices in your home or place of employment:

- ◊ All family members/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. Cell phones 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 phone. In a panic, people commonly forget the simplest of directions or cannot state them clearly.
- ◊ Provide the local fire company with a detailed map of the farm, including pesticide storage areas, fertilizer storage areas, manure pits and lagoons, and clean water pond sources. The fire company could have these on file, or they 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 the correct fire extinguishers on all tractors.

Being prepared for a fire is good insurance that all people involved will react in a focused and safe manner.

Are you and your family and your employer fire prepared?

Safety Activities

1. What three factors make up the fire triangle?
2. Perform a housekeeping inspection of the home shop, school shop, or a local farm shop to locate any hazards that could be a potential for fire. Make a list of those hazards. Ask for permission to eliminate the problem.
3. The kitchen stove catches fire while eggs are being fried. Should you throw water on the fire to control it? Why or why not?
4. How could you control a kitchen grease fire?
5. An electric motor is on fire. What fire extinguisher should you use and why?
6. Could a shovel full of soil be used to put out a small fire on the top of a farm machine? Explain your answer in terms of the fire triangle.
7. Does your computer room at school or at home have a Halon-type fire extinguisher available for use? Why is a Halon extinguisher a good idea in the computer area?
8. Recite the PASS process for using a fire extinguisher.
9. Conduct a survey of a local farm to determine how many fire extinguishers are found in the shop and on the tractors. Look for an inspection date. Are the extinguishers currently inspected?

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

"Fire Safety in Horse Stables." Penn State Extension, **extension.psu.edu/fire-safety-in-horse-stables**.

Safety Management for Landscapers, Grounds-care Businesses, and Golf Courses. John Deere Publishing, 2001.

Hay Storage Fires

Learning Goals

- Understand that improperly stored hay can ignite by spontaneous combustion
- Learn how to prevent hay storage fires
- Understand what to do if stored hay is getting too hot

Related Task Sheets

- 3.7: Fire Safety
- 3.7.1: Fire Prevention and Control

Introduction

Fires destroy property, stored crops, and livestock, which may cost farms thousands of dollars in lost revenue. Fire investigations have pinpointed many causes of barn fires, including "spontaneous combustion," electrical malfunctions, poor housekeeping, and careless work habits.

Plant material (hay and straw) will continue to respire (produce oxygen) for a short time after it is stored. Plant respiration and bacterial action creates heat as it uses oxygen. Given enough heat, material will begin to combust.

This task sheet discusses recognizing hay fire risks and the proper handling of a hay crop as a means of preventing fires caused by spontaneous combustion.

The Chemistry of Hay Fires

Fresh-cut forage crop cells continue to respire until the crop material dries or is cured. This chain of events that occurs within the forage depends on many factors. Moisture content is the most critical and only influence discussed from a fire safety standpoint.

Hay placed in storage should have a moisture content under 25 percent. Higher levels of moisture require an oxygen-limiting storage system. The heat generated by the crop plus the presence of oxygen increase the risk of a fire.

Drying or curing the forage takes several weeks, but the risk of fire in stored hay usually occurs within two to six weeks of storage. Stored hay of normal moisture levels undergoes some heating, but the heat is normally less than 125°F (see table below).

Some hay growers apply chemical or biological additives and preservatives to the hay at harvest time to increase the rate of field drying or to bale and store the hay at higher moisture levels. The hay may still heat in storage.

Note: Stored cured hay can become damp due to a leaky barn roof, from ground moisture, or from high humidity and can still burn due to spontaneous combustion.

Store baled hay when the moisture content is below 20 percent.

Figure 3.7.2.a. Hay storage fires result in devastating damage. The building, crop, and livestock losses, as well as the loss of income-producing facilities, can be tremendous. Credit: Alpha Fire Company

Critical Temperatures, Conditions, and Actions to Take with Hot Hay

Temperature	Condition and Action
125°F	No action needed.
150°F	Temperature will most likely continue to rise. Check temperature twice daily. Move hay to allow air circulation to cool the hay.
160°F	Check temperature every few hours. Move hay to allow air circulation to cool the hay.
175–190°F	Hot spots or fire pockets are likely. Alert fire service of a possible hay fire incident. Stop all air movement around the hay. Remove hot hay with assistance of fire service personnel.
200°F or above	Fire is present at or near the temperature probe. Inject water to cool hot spots before moving the hay. Fire service should be prepared for hay to burst into flame when contacting the air.

Source: "Beware of the Dangers of Hot Hay," Penn State Extension.

Hazards of Hay Fires

Three potential hazards exist from hay fires:

- Sudden flare-ups of flames with exposure to fresh air
- Burned-out cavities in the hay that present a fall or entrapment hazard
- Toxic gases

Flare-up of Flames

The potential for hay to spontaneously combust increases at temperatures between 150 and 170°F. Hay in this temperature range should be moved to allow for cooling. At the higher end of this temperature range, moving the hay exposes the heated material to oxygen and a sudden flare-up can occur. Fire service officials should be notified if possible. Always have a charged water hose available.

Burned-out Cavities in the Hay

Deep within the stored hay mass, temperatures may have reached levels where the hay has already burned. This burning has been a smoldering fire. Hollow cavities may have formed. These cavities can entrap a person who collapses the top of the hay pile by walking over it.

To prevent entrapment in burned-out cavities, place a wooden plank over the hay before walking over the area. A rope harness tied to a secure location is also recommended. Falls into a burned-out cavity may lead to broken bones, burns, and lung damage.

Since the hay may have been chemically treated, trained fire service personnel with a self-contained breathing apparatus should be called to provide the assistance needed in solving the potential fire problem.

Toxic Gas Exposure

Smoldering and burning hay can be the source of toxic gases. Carbon monoxide can be concentrated within the smoldering fire and surrounding area. Chemically preserved hay crops may produce toxic gas vapors. Deadly gases add to the fire risk.

Crop preservative Safety Data Sheet (SDS) information should be available to fire service personnel.

Note: Young farm workers should not be assigned to monitor temperatures of hay in storage. This poses an unnecessary risk to inexperienced workers.

Monitoring Hot Hay

Smoldering hay gives off a strong, pungent odor. This odor indicates that a fire is occurring. At this point, stay off the hay, as a burned-out cavity may be found beneath where you would be walking.

The first reaction is to remove the heated hay. The temperature of the hay must be known before removal occurs. At lower temperatures, removing hay helps move heat away from the hay by normal ventilation. When stored hay reaches 175°F, any increased ventilation could result in rapid combustion.

Hay temperatures must be monitored by an experienced person. Close coordination with a local fire service is of importance should the hay temperatures continue to rise.

Figure 3.7.2.b. A homemade probe can be easily constructed.

Figure 3.7.2.c. Use an organized pattern to monitor and record hay temperatures if overheating is suspected. Credit: Penn State Extension Ag Safety Team

An experienced worker, not a youth worker, should monitor rising temperatures in hay storage.

Preventing Hay Fires

To prevent hay fires in storage areas, follow these approved practices to reduce the potential for forage crops to heat in storage.

Harvest Practices

To reduce crop moisture levels rapidly, mow the forage early in the morning to allow one or more full days of drying time before baling. Storing dry hay reduces the risk of overheating.

Conditioning Practices

Although it is difficult to achieve, the best weather conditions for hay curing is less than 50 percent relative humidity with some wind movement. Monitor the weather conditions and predictions to help schedule haymaking operations.

Hay mower conditioners, or crimpers, crush the forage stem and speed the drying time of the crop. Windrow inverters, tedders, and hay rakes also speed the drying process. Each haying operation can shatter leaves from the stem and reduce the quality of the hay.

Chemical drying agents and preservatives may help condition the forage crop. These materials can be used to speed up field drying rates. Most additives and preservatives increase the moisture level at which the forage can be safely preserved. Inoculant and acid-based preservatives increase the safe hay baling moisture levels to 25–30 percent. Temperatures that ignite spontaneous combustion may be avoided when using these materials, but internal heating of the forage may cause heat-damaged protein. Heat-damaged protein reduces the nutritional value of the feed.

Baling Practices

Bale the hay at 18–20 percent moisture to reduce the risk of conditions that support spontaneous combustion.

Storage Practices

Store hay under cover to prevent rain damage and potential for heating. Leaky roofs and plumbing leaks can increase moisture levels of the stored forage to a point of reheating, which may lead to spontaneous combustion.

Prevention of hay storage fires begins in the field with sound crop management.

Safety Activities

1. Use a crop production reference to locate information about optimum moisture levels to harvest and store the major crops in your area. Make a chart to show what the moisture level should be for storage of those crops.
2. Contact your local agricultural chemical dealer to request brochures or labels for crop additives and preservatives. Write a report on these materials showing what they do.
3. Contact your local fire service personnel to ask about barn fires in your area. What were the causes? Were hazardous chemicals involved? What special training do the fire service personnel receive?
4. Develop a hay temperature monitoring kit of a probe, a thermometer and cord, and a record sheet for use by farmers in your community.
5. Write a news release for your community farmers telling them about hay storage fire hazards.
6. Study silo fires and write a report comparing a hay storage fire with a silo fire.

References

"Beware of the Dangers of Hot Hay." Penn State Extension, **extension.psu.edu/beware-of-the-dangers-of-hot-hay**.

"Fire Safety in Horse Stables." Penn State Extension, **extension.psu.edu/fire-safety-in-horse-stables**.

"Silo Fires." Penn State Extension, **extension.psu.edu/silo-fires**.

Confined Spaces

Learning Goal

◊ Understand the hazards of confined space work areas

Related Task Sheets

◊ 1.2.1: Hazardous Occupations Order in Agriculture
◊ 1.2.2: Occupational Safety and Health Act
◊ 3.3: Respiratory Hazards
◊ 3.3.1: Respiratory Protection

Introduction

Certain work spaces on farms may present hazards to those working in and around them. These spaces are often referred to as confined spaces. Silos, manure pits, grain bins trenches, grain dryers, milk tanks, and liquid manure spreaders are examples of areas that would be considered confined spaces. The Hazardous Occupations Order in Agriculture prohibits youth workers under the age of 16 from working inside certain areas that would be considered a confined space.

This task sheet discusses the hazards of working in confined spaces.

If you must climb into or out of a space to do work, you are confined. Don't take the risk!

Definition

A confined space as defined by OSHA is:

◊ Large enough and so configured that a person can enter and perform assigned work
◊ Limited in openings for entry and exit purposes
◊ Not intended for continuous human occupancy

An agricultural confined space is defined as any space found in an agricultural workplace that:

◊ Was not designed or intended to serve as a regular workstation
◊ Has limited or restricted means of entering or exiting the space
◊ Has the potential for physical and/or toxic hazards to workers who intentionally or unintentionally enter the area

Although specific standards for agricultural confined space work areas are not part of the OSHA regulations, every person working on farm worksites with confined space hazards should receive safety training. Silo, grain bin, manure storage, and farmstead chemicals are specifically addressed in the remaining portions of Section 3.

Think about the definitions presented. Have you been assigned to work in an area that meets the definition of a confined space?

◊ Do you have to enter an area to work by crawling, stooping, crouching, or climbing into it?
◊ Does the work area have an exit other than where you entered?
◊ Is there adequate, natural ventilation in the work space?

◊ Does that work space produce dangerous air contaminants as you do your work?
◊ Are there breathing hazards to be found in the confined space?
◊ Is the space capable of normal body movements for long time periods?

Young workers should evaluate the risk of the work area with an adult by asking these questions. Adults should determine methods to eliminate or control the hazards before beginning the job.

Figure 3.8.a. Confined spaces can kill! Never enter a confined space alone, and never enter if you are under the age of 16. Illustration by Jeff Mathison

Youth under the age of 16 are prohibited from working in confined spaces.

Storage Tanks, Milk Tanks, and Oil Tanks

Some confined space work areas may appear to be safe for periodic inspection, cleanup, maintenance, or repair tasks. Storage tanks, milk tanks, and oil tanks may pose risks to health and safety. Consider these problems:

◊ An oxygen-deficient atmosphere
◊ A flammable atmosphere
◊ A toxic atmosphere

Figure 3.8.b. 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: Penn State Extension Ag Safety Team

Oxygen-Deficient Atmosphere

The air we breathe contains oxygen. At a minimum, the air should contain 19.5 percent 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. Cleaning rusty metal with a grinder will fill the atmosphere with particulates, which may reduce the available oxygen.

Toxic Atmosphere

Depending on 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 Task Sheet 3.13).

Flammable Atmosphere

Flammable materials can be gas, vapor, or dust in the proper mixture with oxygen. A source of ignition from welding or an electrical tool can ignite. An explosion inside the confined space can result. Petroleum product storage tanks that must have repairs may contain highly flammable materials. These tanks may appear to be empty, but the residual vapors can be ignited. Vapors trapped in sludge-like material that must be scraped from tank walls are released and increase the risk of ignition. Never weld on any storage tank. A certified welding professional should be contacted for such a job.

Working in Trenches

Trenches may be storage pits for silage or composting. The trench could be a ditch that is being dug for installation of electric utility or water lines. You may have been assigned to work in that trench. Is it a safe place to work?

Trench sidewalls can cave in and trap workers. Death by suffocation is possible. Trench cave-ins have trapped countless workers. Follow these safety plans when working in a trench:

- ◊ Do not enter a deep ditch that has sidewalls higher than your head unless the trench has steel retainer walls (trench box) to stabilize it.
- ◊ "Steps" or a sloping ramp should be cut into trench to allow workers to exit easily.
- ◊ Use a hard hat and a lifeline harness to protect yourself.
- ◊ While working in a trench, 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. It is recommended to only allow adults to complete jobs associated with confined spaces. The following practices may help reduce the risks.

Figure 3.8.c. Trenches and pits in agriculture pose risk of sidewall cave-in and entrapment of the worker. Death by crushing can result. Suffocation can also occur. Credit: Penn State Extension Ag Safety Team

Ventilation

Ventilate confined space work areas before entering the area.

Isolate the Confined Space from Entry

Post signs at the confined space work area to warn of the hazard. Lock-out/tag-out electric circuits to prevent startup problems.

Test the Atmosphere

If possible, monitor the atmosphere for oxygen deficiency. Most farms will not own this equipment; contact fire service companies to see if they have the equipment.

Self-Contained Breathing Apparatus

Toxic atmosphere confined spaces should not be entered unless the worker is equipped with self-contained breathing apparatus and has been trained in its use.

Figure 3.8.d. Confined space entry into oxygen-deficient areas requires SCBA. Training is necessary to use this equipment. Do not work alone in a confined space. Illustration by Penn State Extension Ag Safety Team

Safety Equipment

Safety equipment needs are greater for confined space work. Respirators for a specific purpose are recommended. Hard hats and steel-toed shoes may be required. Communication equipment will be needed if direct contact with a helper cannot be made. Spark-proof tools will prevent ignition of flammable gases and dust. In addition, a safety harness and safety lines are advised.

Confined space work requires training and that body harness equipment be available.

Standby/Rescue

Confined space work dictates that a helper or helpers must be available. Ladders, ropes, and lifts make immediate rescue possible. Do not work alone in confined spaces.

Hazardous Occupations Order in Agriculture Prohibitions

Some occupations in agriculture are considered particularly hazardous for youth under the age of 16. The Hazardous Occupations Order in Agriculture prohibits youth younger than age 16 from working inside the following areas:

- ◊ 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. Confined space work areas often do not appear to be hazardous until an injury or fatality reminds us of the risks. Reread the information above about reducing confined space work risks.

Safety Activities

1. Interview a local fire service member to learn more about self-contained breathing apparatus and its use.
2. Review the occupations that are considered hazardous for youth under the age of 16.
3. Visit OSHA's website (**www.osha.gov**) and search for the regulations regarding confined space work areas. What are the points that farmers should consider for educating their employees and families?

Reference

"A Guide to Safety in Confined Spaces." NIOSH Publication No 87-113 (July 1987), **www.cdc.gov/niosh/docs/87-113/default.html**.

Silos

Learning Goals

- Understand how silo storage structures and equipment present hazards
- Develop safe work skills to use while working around silos

Related Task Sheets

- 1.2.1: Hazardous Occupations Order in Agriculture
- 2.1: Injuries Involving Youth
- 3.1: Mechanical Hazards
- 3.3: Respiratory Hazards
- 3.3.1: Respiratory Protection
- 3.10: Grain Bins
- 3.11: Manure Storage
- 5.4.1: Using Power Take-Off (PTO) Implements

Introduction

The farm silo is a controlled fermentation and storage space for finely chopped forages. These forages become acidic and the low pH during storage prevents silage spoilage as long as the silage is not exposed to oxygen.

Silos may come in many forms, such as an upright tower or a trench, bunker, or stack or bag on the ground. Each type of silo presents unique hazards that can affect your safety.

This task sheet discusses the safety considerations that a worker must understand when working with silos and ensiling crops.

Figure 3.9.a. Farm silo. Credit: Penn State Extension Ag Safety Team

Silage Chemistry

Silage fermentation is the process of controlling bacterial actions that naturally break down the plant fibers of corn, hay, and other crops. Plant and bacterial respiration action will occur once the forage is cut and placed in storage. This cause silage temperature to increase to 80–90°F. During this stage, silage gas is produced (see below). When placed in storage, the forage is packed to remove air space. Fermentation will begin once the silage is packed and the oxygen is depleted from the silage mass. The silage pH will lower. This condition 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, the increase in these gases occurs.

Carbon dioxide, an odorless, colorless, heavier-than-air gas, and nitrogen dioxide, a heavy, yellowish-brown-colored gas with a bleach-like odor, are abundantly released. This heavier-than-air gas (carbon dioxide) settles to low spots, including feed rooms. Both of these gases present an asphyxiation (lack of oxygen) hazard. Nitrogen dioxide exposure can result in severe irritation and inflammation of the lungs. High concentrations of inhaled gas and prolonged exposure can result in death.

Working Safely

Understanding how silage is produced helps prevent exposure to deadly silo gases. Follow the precautions below to prevent health problems from occurring due to silage gas.

Ventilation

First, before entering the silo, ventilate the silo and all adjacent areas thoroughly by running the silo blower for 15 to 20 minutes before going into the silo, and keep the fan on while a person is inside. Opening all doors to the level of the settled silage and opening the windows in the feed rooms will increase ventilation. There is no guarantee that silo blower ventilation will make it safe for anyone to enter the silo without a self-contained breathing apparatus.

Personnel

Allow adults to enter the silo. At all times, someone should remain outside the silo and maintain visual contact with the individual inside the silo. This will allow someone to get help should the person inside the silo need assistance.

Personal Protective Equipment

If it is necessary to enter a silo containing silage in an emergency, an adult should enter the the silo wearing a self-contained breathing apparatus and a safety harness attached to a lifeline secured to an anchor point.

Signage

Post appropriate signage warning people of the potential for silo gases. By posting "Danger—Deadly Silo Gas" signs around the base of the silo, you are warning visitors, family members, and workers to stay away from the area.

Power Supply

Prior to a person entering a silo, make sure the power supplies for all unloading mechanisms are locked out and tagged "out of service."

Shut down the tractor before attempting to unplug a silage blower or wagon.

Working Safely with Silo-Filling Equipment

Keep children away from silo filling operations.

Filling silos involves many tractors and many implements working together. Forage harvesters, self-unloading wagons, forage blowers, unloading platforms, bagging units, and silo distributors and augers are in constant use. The work area is also crowded. These machines are powered by PTOs (power take-offs) or other moving shafts. An increased exposure to machine hazards occurs during silo filling.

Silos produce the best silage when filled quickly and packed tightly. Much work occurs in a short time period. Corn silage harvest can coincide with early fall and rainy weather. An increased need for safe work habits exists in changing work conditions. Let's examine each area that can pose a problem.

Figure 3.9.b. The work of filling a silo is done in close quarters. Two tractors are often involved, with the PTO shafts operating the self-unloading wagon and the silage blower. Extreme caution is needed to do this work safely. Credit: Andy Mylin

The Unloader

Before filling the conventional silo, the unloader must be raised by cable and pulleys to the top of the silo. One person at ground level can operate the electric control to do this job, but a second person observing the procedure from the blower pipe platform can signal if the cables become tangled. No one should be in the silo under the unloader as it is raised. Do not ride the unloader to the top of the silo since the cables could break.

Self-Unloading Wagons and Blowers

Self-unloading wagons contain moving aprons, beaters, conveyors or augers, and an assortment of chains and sprockets. PTO shafts are involved. The silage is moved by conveyor or auger to the PTO-powered blower fan blades. These blades turn at high speeds to "blow" the silage to the top of the silo or farther back into the trench. Silage-bagging equipment also has numerous moving parts that pose risks.

Moving the moist, finely chopped crop can result in the equipment becoming plugged. Do not attempt to use your hands or feet to unplug a machine. Before attempting to unplug a clogged machine, follow these safety procedures:

- ◊ Disengage the power to the machine.
- ◊ Turn off the tractor engine.
- ◊ Wait for free-wheeling blower fan blades to come to a complete stop.

Falls

Falls are a major source of injury for young agricultural workers.

Note: The Department of Labor Hazardous Occupations Order in Agriculture prohibits youth ages 14 and 15 from using a ladder higher than 20 feet from the ground.

Upright silos can be 80 to 100 feet tall. The silo's attached ladder may have a protective cage surrounding it. This cage offers some fall protection to the climber.

Trench or bunker silos often exceed 20 feet in height as well. Ladders may be placed against the silo walls for use when a plastic covering is installed.

Remember to use a three-point contact on the silo's ladder when climbing (two feet and one hand, or two hands and one foot). Face the ladder while climbing. Stay inside the protective cage surrounding the silo's ladder.

Figure 3.9.c. When climbing silos, use the ladder, stay inside the enclosed protective cage, and maintain a three-point contact with the ladder. Credit: Ag Youth Work Guidelines

Trenches, Bunkers, and Stacks

Silos come in many forms. Upright silos require expensive maintenance. Horizontal silos have capacity limited only by the location of the trench, bunker, or silage bag. Silage can even be stacked on a firm base. Each silo type has its own set of operation rules.

Horizontal silos, like trenches, bunkers, and stacks, must be packed tightly to exclude oxygen from the crop. Equipment rollover is a safety hazard because the silage pile is "packed." Follow these practices to avoid serious injury or death to the operator and to prevent costly equipment damage:

- ◊ Use only tractors equipped with ROPS and seat belts.
- ◊ Use the seat belt when packing silage.
- ◊ Use low-clearance, wide front-end tractors.
- ◊ Add weights to the front and back of the tractor to improve stability.
- ◊ Do not use wheel-type tractors on silage surfaces with slopes greater than 1 to 3 (1 foot of rise in 3 feet of run).
- ◊ Back up sloped silage surfaces and drive down those areas.
- ◊ Distribute silage evenly in 6-inch layers for uniform packing.
- ◊ Front-wheel and assist-drive tractors provide extra traction and stability for packing and towing on silage.
- ◊ Only mature, experienced operators should be permitted to operate the packing tractor, unloading tractor, or forage wagon on the silage surface.

Trenches, bunkers, and stacks of silage are danger zones in crop harvest. Extra caution is needed to do this job safely and successfully.

Only mature, experienced operators should be assigned to pack silage in a horizontal silo.

Figure 3.9.d. Bunker silos must be packed tightly to limit the amount of oxygen available to bacterial and plant fermentation. Driving of a packing tractor back and forth can lead to tractor rollovers. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Visit a local farm with upright silos to learn more about how the silo is loaded, unloaded, ventilated, and kept safe from young workers or visitors. Develop warning signs that could advise operators or visitors about the dangers of the upright silo.
2. Visit a farm with horizontal silos to learn how they are filled, packed, and unloaded. Develop warning signs that could advise operators or visitors about the dangers of the horizontal storage areas.
3. Match the silo type with its description and related hazard.

   _____ Trench Silo

   _____ Bunker Silo

   _____ Stack Silo

   _____ Silo Bag

   _____ Oxygen-limiting silo

   _____ Tower silo

   1. An upright silo with a roof and is accessible to workers. Presents silo gas hazard.
   2. Can be a pit dug into the ground, which means an embankment collapse hazard is possible.
   3. Plastic wrapped silage where machinery operation by PTO is a safety risk.
   4. A horizontal silo with wooden timber or concrete sides. Packing this silo creates an increased risk of tractor rollover.
   5. Tightly packed silage piled on the ground where the risk of tractor rollover is increased.
   6. A lined, sealed steel or concrete silo with limited entry. Suffocation is likely if entered.

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

"Silo Gases: The Hidden Danger." Penn State Extension, **extension.psu.edu/silo-gases-the-hidden-danger**.

Horizontal Silo Safety

Silo filling must be done rapidly; safe practices are necessary.

Learning Goals

- Understand the hazards involved with horizontal silos
- Fill horizontal silos safely
- Practice safe silage removal procedures

Related Task Sheets

- 3.9: Silos
- 3.9.2: Packing Forage in a Horizontal Silo
- 4.12: Tractor Stability
- 4.13: Using the Tractor Safely
- 5.4: Making Power Take-Off (PTO) Connections
- 6.5: Dump Trucks and Trailers—Farm Use Only
- 6.9: Silage Defacers

Figure 3.9.1.a. Three forms of horizontal silo are shown: a trench silo (A), a drive-over silage pile (B), and a concrete bunker silo (C). Horizontal silos can vary in height from 4 to 5 feet high to over 40 feet. Credits: (A) Penn State Extension Ag Safety Team; (B) and (C) Courtesy of K. J. Bolsen

Introduction

Research shows that filling the silo quickly and packing the forage tightly results in a higher-quality silage. However, fast-paced operations increase the risk for injury or fatality. PTO (power take-off) and machinery entanglements, highway mishaps, dump truck incidents, silage baggers, and horizontal silos have all played a role in injuries and fatalities during busy silage-harvesting operations. While corn is the crop most often harvested for silage, hay crops can also be placed into horizontal silos.

This task sheet discusses horizontal silo safety for those who may be required to work as part of a team during silo filling and feed-out.

Horizontal Silos

Horizontal silos vary in form. Whether it is a trench cut into the ground, forage piled on top of the soil, or a bunker-type silo with concrete or wooden sides, the process of filling and feeding from a horizontal silo is similar. Sizes of these trenches, bunks, and drive-over piles can vary according to the size of the livestock operation. Flexibility in expanding the storage area often makes horizontal-type storage more desirable than upright silos, but there are hazards involved in filling and feeding silage from horizontal silos.

Although wagons are often used to haul and dump forage, larger farms are increasingly using dump trucks for transport. As the forage depth and the side slope grow, the risk of tractor or dump truck overturn increases. As the forage depth becomes even greater, bunker sidewall capacity can be exceeded, adding to the hazard potential. Dumping and packing equipment must operate away from these sidewalls to reduce stress on the structure and to avoid overturning off the sidewall.

Preharvest Inspection

Regardless of the style of horizontal silo, wear and tear occur over time. Earthen trench sides can slip, earthen trench and drive-over pile site approaches can become muddy and rutted, and concrete or wood-sided bunkers can become cracked over time. These should be repaired before use to maintain traction and stability for trucks and tractors.

Bunker silos should be equipped with iron pipe or steel sight rails. These sight rails give the operator a visual clue to the edge of the bunker while backing, unloading, and packing forage into the bunker. However, these rails are not intended to stop an overturning tractor or dump truck from toppling over the side of the bunker. They can also serve as fall protection for workers as they move around the sidewalls while working with plastic covering and weights used to seal the surface.

Figure 3.9.1.b. Bunker silo sidewalls are under great stress from silage weight and packing. A sidewall collapse could send a truck or tractor into an overturn. This situation must be repaired before harvest begins. Credit: Penn State Extension Ag Safety Team

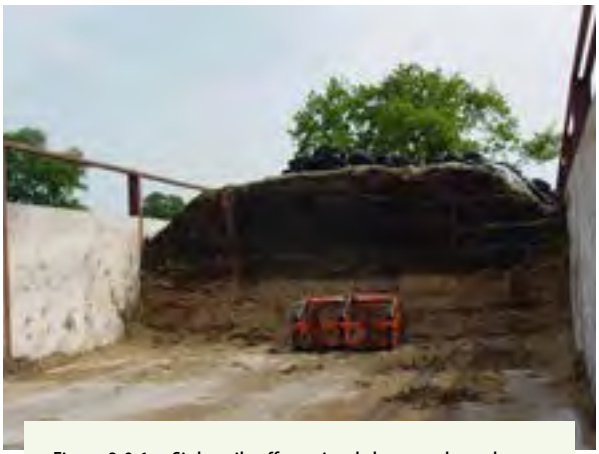

Figure 3.9.1.c. Sight rails offer a visual clue as to how close to the edge of the bunker you are operating the dump truck or packing tractor. These should be kept in good repair. Credit: Penn State Extension Ag Safety Team

Fill and Pack Techniques

A "progressive wedge" of forage is formed during the filling of the silo to help achieve the required amount of crop compaction. The wedge provides a safe slope for unloading and packing operations. A progressive wedge with a maximum slope of 1 to 3 minimizes the risk of rollover. The resulting slope has a rise of 1 foot in every 3 feet of horizontal run.

The operator must remember that while the surface is being packed, it still can have ruts and soft areas that can lead to equipment rollover. A rut or soft spot on the lower side of the truck or tractor can cause a sudden, unexpected shift of the vehicle to the side. There is seldom enough time to react to avoid this shift. Forage should be leveled before the next load is dumped and compacted.

Ideally, do not fill the trench or bunker higher than the sides of the retaining wall.

Figure 3.9.1.d. Dump trucks are commonly used to fill horizontal silos. A truck equipped with a webbed unloading floor is more stable than a raised-bed truck. Operate the truck up and over the drive-over pile, not across the slope, and up and then down on a trench fill silo. Credit: Penn State Extension Ag Safety Team

Figure 3.9.1.e. Use a ROPS-equipped tractor fitted with dual wheels, extra weights, and a leveling blade to spread forages for packing. Be sure the seat belt is fastened when operating in a ROPS cab. Keep the pile level and free of ruts before the next load arrives to be dumped and compacted. Credit: Penn State Extension Ag Safety Team

Feeding Silage Safely

Work safely through the feed-out process. Silage feed-out injury may occur from the silage face collapsing due to undercutting, equipment rollover, and entanglement. Observe where other workers and obstructions are located before beginning to work.

Silage face collapse may occur when equipment cannot reach the top of the feed-out face to remove an even amount of the feed. The silage that is removed from the bottom of the feed-out face allows heavy, unsecured silage from the top to break free. Workers, by-standers, and even equipment operators can be buried beneath tons of silage. Numerous deaths have occurred from an avalanche of silage trapping people and equipment. Using a silage defacer or equivalent accessory mounted on a material handler's boom to reach to the top of the silage face is a safe practice.

Equipment should not be operated from atop the silage. Edges of the feed face can be loosened, allowing the silage face to collapse due to the weight of the equipment.

Figure 3.9.1.f. Equipment that cannot reach to the top of the silage face will undercut the feed-out face at the bottom. A collapse of the silage can result. Credit: Courtesy of K. J. Bolsen

Figure 3.9.1.g. A silage defacer mounted on a skid steer can reach the top of the silage face, but a material handler with a boom may be needed to remove silage from higher reaches. Credit: Penn State Extension Ag Safety Team

Using Silage Feeding Equipment

Feed equipment used to blend silage with other feedstuffs may be powered by a PTO shaft. The risk of entanglement in the turning shaft increases with use. PTO guards must be in place. Disengage the PTO and stop the tractor engine if adjustments or repairs must be made to feeding equipment. Never step across a turning PTO shaft for any reason.

Remind children and by-standers of the dangers of machinery and silage face collapse.

Other Considerations

Silage can collapse. Fatalities have occurred while taking samples for nutritional analysis. Nutritionists, herdspersons, and students who must gather silage for forage quality evaluation should have an equipment operator scoop out and bring the silage sample to them. Avoid the feed-out face of the silage if it exceeds your height.

Working near the top edge in a trench, bunker, or pile while removing the plastic cover or weights can cause the silage to collapse if it is weakened from undercutting. Freezing and thawing can also weaken the face of the silage. Do this job only if you can stay a safe distance away from the edge.

When working around the silage face, have a fellow worker assist in case of collapse.

Figure 3.9.1.h. This is not a safe place to be. What seems to be an activity in studying quality silage production or gathering feed samples could quickly become the scene of a tragedy should the silage feed-out face collapse. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Conduct an Internet search for horizontal silo images. Without violating copyright laws, use the pictures to make a scrapbook or poster display of the size and scope of corn or hay silage storage facilities. Label the pictures with important information found in this task sheet (for example, label the parts of the bunker silo, calculate and label the slope, or identify hazards).
2. Draw a map of your community and, with the help of your classmates or club members, identify where the silage trenches, bunkers, and drive-over piles are located. Estimate the total tonnage of silage that the largest bunker contains. Corn silage often weighs between 14 and 18 pounds per cubic foot as an average density.
3. Locate on the map you made in Activity 2 where the local fire and rescue companies are to be found. How far are they from the farthest farm that has a horizontal silo?
4. With your class, develop a 10-minute presentation about horizontal silo safety and the potential for silage face collapse, and present the program to a local emergency rescue group or community farm or ranch group.

References

"Farm Dump Truck and Trailer Safety." Penn State Extension, extension.psu.edu/farm-dump-truck-and-trailer-safety.

"Horizontal Silo Safety." Penn State Extension, **extension.psu.edu/horizontal-silo-safety**.

Packing Forage in a Horizontal Silo

Learning Goal

◊ Develop safe operating skills when packing forage in a horizontal silo

Related Task Sheets

◊ 3.9: Silos
◊ 4.2: Tractor Hazards
◊ 4.12: Tractor Stability

Introduction

Tractors are often used for packing freshly cut forage in a trench, bunker, or drive-over pile. The packing tractor is operated back and forth over the forage surface as the crop is harvested and dumped on a progressively deeper wedge-shaped surface. As the forage depth grows and the sides become steeper, risks increase for a tractor rollover.

This task sheet discusses forage packing safety.

Tractor stability while packing forage may be a matter of life and death.

The Basics of Top Quality Silage

Chopped forage must be packed tightly in trenches, bunkers, or drive-over piles. Rapid filling and packing limits air (oxygen) from the forage mass. Excessive air leads to a loss of plant sugars and undesirable fermentation by-products and the potential for spoilage, which limits animals' consumption and utilization of the silage.

The packing equipment must be heavy enough to achieve a dense pack. Heavier tractors equipped with dual wheels and a leveling blade attachment offer greater stability on the forage surface than smaller equipment. The ROPS-enclosed cab and seat belt offer a "zone of protection" to the operator. Smaller, older model tractors with single rear tires do not pack the chopped forage as densely and may cause ruts in the forage surface. The ruts in the surface coupled with the ever-increasing side slope increase the risk of rollover. Older tractors may not be fitted with a ROPS cab, which further places the operator in danger.

Figure 3.9.2.a. Rapid and thorough packing of forage results in a high-quality ensiled crop, which when fed to livestock produces top yields of milk or meat. The packing tractor must be stable enough to operate on the forage surface. Credit: Penn State Extension Ag Safety Team

Figure 3.9.2.b. Steep sides should never be allowed to develop as the forage surface increases in depth. Steep slopes contribute to the potential for tractor rollover. Credit: Penn State Extension Ag Safety Team

Safely Packing Forage in a Horizontal Silo

Harvesting forage and filling silos must be done quickly. Follow these considerations to do the job safely:

- ◊ Use a ROPS-equipped tractor and fasten the seat belt.
- ◊ Recognize traffic flow of all vehicles involved in the operation.
- ◊ No person on foot should be on the packing surface while equipment is operating.
- ◊ Develop a forage surface with side slopes not to exceed a 1 to 3 (1:3) slope. This means no more than 1 foot of height for every 3 feet of length.
- ◊ Do not exceed the sidewall height of the bunker.
- ◊ Sighting rails at the top of the bunker provide a guide to help the operator stay back from the side.
- ◊ Do not let ruts develop. Ruts may throw the tractor to the side and cause an overturn.
- ◊ Dump wagons and dump trucks must be kept as level as possible when unloading chopped forage.

Figure 3.9.2.c. Coordination of dumping of forage with the packing operation is necessary. Movement of several trucks and more than one packing tractor means attention to their location is necessary. Credit: Courtesy of K. J. Bolsen

Develop a forage surface with side slopes not to exceed a 1 to 3 (1:3) slope. This means no more than 1 foot of height for every 3 feet of length.

Figure 3.9.2.d. Forage piles should not exceed the sidewall height of the bunker. Sighting rails provide a guide to the operator. Do not operate the packing tractor close to the steep sides. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Ask your instructor or club leader to schedule a field trip to observe the filling and packing of forage in a horizontal silo. If the field trip is not possible, search the Internet, YouTube, or a similar source to find a horizontal silo being filled.
2. Search for "horizontal silage safety" on the Internet.
3. Solve this problem: A corn grower has 1,600 acres of corn silage to harvest. Yield is 24 tons per acre The average forage wagon hauls 7 tons and the average dump-equipped truck can haul 12 tons. How many loads must be hauled using only the forage wagon? Using only the dump-equipped truck?
4. If a silage depth is 40 feet to the top center, and a safe side slope of 1:3 ratio is recommended, how far out from the center does the silage extend? This is the distance for one side only, so double the results to get the overall width of the storage area.

Reference

"Horizontal Silo Safety." Penn State Extension, **extension.psu.edu/horizontal-silo-safety**.

Grain Bins

Learning Goals

- Understand that flowing grain can be a deadly hazard
- Understand how to prevent flowing grain hazards while working with bins, wagons, and trucks

Related Task Sheets

- 3.3: Respiratory Hazards
- 3.3.1: Respiratory Protection
- 3.8: Confined Spaces

Introduction

Unloading grain from storage bins and wagons exposes workers to the risk of entanglement as well as entrapment or engulfment within the grain. 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 have resulted in an average of 12 deaths each year around the country.

This task sheet discusses the hazards of flowing grain in storage bins, wagons, and trucks.

Within seconds, a person can be helplessly trapped in flowing grain.

Flowing Grain

Harvesting grain 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. However, flowing grain has many hazards that may go unnoticed.

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 3.10.a.).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 your knees are covered by grain, it is almost impossible to free yourself without the assistance of others. If the knees are covered and the grain is still flowing, the flowing grain is similar to quicksand and can completely engulf a person very quickly (Figures 3.10.b and 3.10.c).

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 3.10.a. 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: Penn State Extension Ag Safety Team

Figure 3.10.b. Grain flowing out of storage causes a downward-moving floor to move away from your feet. The victim is pulled waist deep in about 10 seconds. Credit: Penn State Extension Ag Safety Team

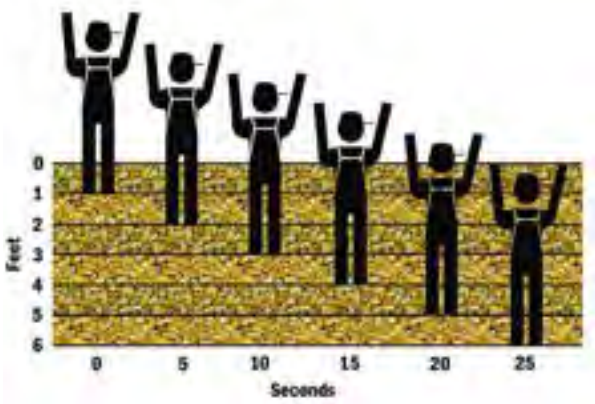

Figure 3.10.c. In a matter of a few seconds, a person standing in the grain bin can be helplessly trapped as the grain begins to flow. A person can be completely engulfed in the grain in about 25 seconds. Death from suffocation most often results. Credit: Penn State Extension Ag Safety Team

A 10-inch auger can move 85 cubic feet or 65 bushels of grain per minute.

Grain Bridging

Grain that is harvested before it has dried down 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 situation is often not recognized as a potential hazard.

As poorly conditioned grain is unloaded from the bin, a cavity may develop (Figure 3.10.d). Often the worker recognizes that 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 3.10.e), and the person is pulled into the flowing grain.

Figure 3.10.d. A "grain bridge" cannot support the weight of the worker. Credit: Penn State Extension Ag Safety Team

Figure 3.10.e. As the grain bridge gives way, the worker is pulled into the pocket and engulfed. The grain auger may have been left running and the flowing grain pulls the victim under the grain. Credit: Penn State Extension Ag Safety Team

Figure 3.10.f. Damp, moldy grain can stick to the side of the grain bin. It can collapse on the worker who tries to dislodge it. Credit: Penn State Extension Ag Safety Team

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 be faced with a wall of crusted grain that must be broken free before it can be unloaded. If the wall of grain is higher than the height of the worker when the worker stands on the grain bin floor, an avalanche may occur as the worker tries to break up the crusted wall of grain. This avalanche could completely engulf the worker leading to injury and possible death (Figure 3.10.f). 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.

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 your life.

- ◊ 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 to break up possible grain bridges from outside the bin.
- ◊ Lockout/tagout all power controls before entering a bin.
- ◊ 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 that is moving grain draws their attention. The chances 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 your local EMS groups.
- Grain vacuum equipment is becoming popular. The vacuum can quickly move grain from trucks to bins or 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 remove thousands of bushels per hour. Hold the vacuum at an angle away from your body. If held close to the body, grain can rapidly be removed from under the operator's feet, quickly pulling the operator down into the grain, possibly entrapping the person in the grain.

Figure 3.10.g. It takes much force to remove a victim of grain bin entrapment. 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: Penn State Extension Ag Safety Team

Fig.3.10.h The grain vacuum moves large quantities of grain from storage to truck, or from truck to grain bin. Credit: Jeff Mathison

Safety Activities

1. Arrange to visit a farm to observe grain being unloaded. Make a list of the hazards that can be found in this farm job.
2. Place a small doll in a grain-filled gravity unload wagon (above the grain unload door and on top of the grain). Open the unload door and describe what happens.
3. Use the Internet to search the land-grant university or college of agriculture in your state to find information about grain moisture levels that are considered safe for preventing moldy grain. Fill in the blanks in the following table:

Grain	Percent Moisture Recommended for Safe Storage
Ear Corn	
Shelled Corn	
Wheat	
Barley	
Oats	
Sorghum	

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

"Hazards of Flowing Grain." Penn State Extension, **extension.psu.edu/hazards-of-flowing-grain**.

Manure Storage

Learning Goal

◊ Understand the hazards of liquid and semisolid manure storage

Related Task Sheets

◊ 2.11: First Aid and Rescue
◊ 3.3: Respiratory Hazards
◊ 3.3.1: Respiratory Protection
◊ 3.8: Confined Spaces

Introduction

The manure storage has reached its capacity. Now the manure must be agitated and removed. It is a routine task on certain farms with livestock housing. The daily caution with machine hazards is coupled with exposure to manure gases as well as drowning.

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 to us.

This task sheet discusses manure storage and the hazardous gases in stored manure produces. Knowledge of manure gases is an important subject for those working in animal agriculture.

A manure pit lacks the oxygen you need to stay alive.

Manure Storage

Manure storage is considered a confined space work area (see Task Sheet 3.8). 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 is built will influence what type of manure storage is used. Modern animal agriculture practices and environmental laws also make storage and management of manure a normal farming routine.

Figure 3.11.a. Manure storage pits are often found below ground level. They are covered until it's time to pump them out. Agitation and pumping release toxic gases. Credit: Penn State Extension Ag Safety Team

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 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 that are directly beneath animals, under the farm building, and closed or covered pump-out pits pose the most risk of manure storage gas hazards. Fatalities to humans and livestock have been documented.

While odor may be a telltale sign indicating the presence of manure gas, several toxic gases are odorless and colorless when present.

Figure 3.11.b. A danger sign posted near a manure storage structure provides a clear warning that immediate death is possible from manure gases. Credit: Penn State Extension Ag Safety Team

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, rot, or fermentation. Fermentation or the rotting process produces manure gases.

Manure gases are poisonous. 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.

Four hazardous gases can be found in stored manure: hydrogen sulfide, ammonia, carbon dioxide, and methane. All of these gases are released into the atmosphere when the 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.

Hydrogen Sulfide

Hydrogen sulfide has a foul odor similar to that of rotten eggs. It is rapidly released from agitated manure and can cause headaches, dizziness, and nausea in as low a concentration as 2 ppm (parts per million). At a concentration of 100 ppm 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 by 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 in high concentrations it causes difficulty breathing, headaches, and even death. It is heavier than air and concentrates in low areas of the storage.

Methane

Methane is a nontoxic, colorless, odorless gas that is lighter than air and rises from storage areas. Headaches and nausea may be experienced with exposure to methane concentrations; it also presents an asphyxiation risk. Methane in manure gas is just as explosive as the methane gas found in a coal mine.

Manure gases can be so concentrated that they can suffocate you 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.

For more case studies, go to **www.cdc.gov/niosh** and type "manure" into the search box.

Do not enter a manure pit for any reason!

Manure Storage Pit 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 backup ventilation system and emergency power source should be considered in the event that the power should fail.
- ◊ 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 the aboveground manure tanks.
- ◊ Do not drive on crusted manure surfaces of aboveground, open-air manure storage tanks, as the crust is not uniformly solid and can break.
- ◊ Warn visitors and guests of the hazards of manure storages.
- ◊ Provide signs at the manure storage area and give verbal instruction to all visitors and guests.

Figure 3.11.c. Open manure storage areas pose a less deadly gas hazard than belowground pits. The major hazard of the open manure storage becomes drowning. Fencing and warning signs alert people of the liquid manure hazard. Credit: Penn State Extension Ag Safety Team

Figure 3.11.d. Only trained person using a self-contained breathing apparatus should enter a manure pit. A lifeline is also a part of safe entry. Do not work alone. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Conduct a survey of the farms in your area. Make a table comparing how many aboveground manure storage facilities exist compared with the number of belowground manure storage structures.
2. One mature cow produces approximately 1 cubic foot of waste per day. For a herd of 500 cows, how many cubic feet of storage space would be necessary to store the waste for 180 days?
3. Using farm magazines, newspapers, the Internet, or any other source, make a collection of news articles that tell about manure storage injuries or fatalities.
4. Contact your local fire and emergency response company to learn more about self-contained breathing apparatus. Write a report for your group or employer.
5. Invite local firefighters to visit a farm to learn more about the hazards associated with manure storage.
6. 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 two or three paragraphs with your answer or explain your answer to your instructor or leader.

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

"Ventilating Manure Storage to Reduce Entry Risk." American Society of Agricultural and Biological Engineers (ASABE), publication ANSI/ASABE S607.

Anhydrous Ammonia

Learning Goal

◊ Understand the uses of anhydrous ammonia and the risks this material can pose

Related Task Sheets

◊ 1.2.1: Hazardous Occupations Order in Agriculture
◊ 1.2.2: Occupational Safety and Health Act
◊ 2.10: Personal Protective Equipment
◊ 2.11: First Aid and Rescue
◊ 3.3: Respiratory Hazards
◊ 3.9: Silos

Introduction

High-yielding crops require specialized nutrition that must be supplemented with fertilizer. This plant growth is improved with appropriate amounts of nitrogen, phosphorus, potassium, and additional micronutrients. Nitrogen is one of the most critical nutrients required for crop production. Nitrogen is responsible for green, healthy, productive leaves. Soils can lack nitrogen or other essential elements for crop production, requiring the addition of fertilizers.

A widely used form of fertilizer is anhydrous ammonia. With 82 percent nitrogen, it is the most concentrated form of nitrogen fertilizer. Anhydrous ammonia is very hazardous because it is caustic and corrosive. Caustic chemicals can burn plant and human tissues.

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 on a supplemental training program. If assigned to the task of working with anhydrous ammonia and you are under the age requirement, tell your employer that you are not permitted to do so.

Even so, youth may be working around anhydrous ammonia and should understand its hazards. Several factors unique to the use and storage of anhydrous ammonia make it important to discuss in this section.

Anhydrous ammonia can permanently damage your lungs.

Use of Anhydrous Ammonia

Anhydrous ammonia (NH3) is a powerful ammonia nitrogen fertilizer. Stored under pressure, anhydrous ammonia exists in liquid form. In the air, anhydrous ammonia becomes a gas. Pressurized tanks (nurse tanks) are used to store and deliver this form of fertilizer to application tanks used on the farm. Field application tanks apply the anhydrous ammonia by injection into the soil. Soil moisture then attracts and holds the nitrogen.

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 NH3 by severe burning of those body areas. Severe health problems will result by improper handling and application of anhydrous ammonia. Anhydrous ammonia can permanently damage your 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 several specific procedures exactly. Safety equipment must be nearby, not stored away from the job site.

Important: The danger of using anhydrous ammonia comes through the risks of handling the material. Youth workers under the age of 16 are not permitted to handle anhydrous ammonia. Some states may have regulations that set the minimum age requirement to 18. Check your local regulatory code for youth labor in agriculture.

NH3 is also added to corn silage at the silo to increase protein levels of the silage.

Figure 3.12.a. Personal protective equipment such as long sleeves and pants are needed for working with anhydrous ammonia. Handlers are at a high risk of being exposed to the burning effects of the NH3 on the skin, eyes, and lungs. Illustration by Jeff Mathison

Anhydrous Ammonia Systems and Safety

The anhydrous ammonia system is made of several components. Each component operates under a pressurized condition. System components include:

- the nurse tank (the delivery tank)
- control valves for withdrawal, fill, pressure relief, and return lines
- pressure gauges
- transfer hoses
- the applicator tank (for field application)

Anhydrous ammonia system components must meet rigorous safety standards. Anhydrous ammonia is corrosive, therefore system parts must be of high-strength steel or other suitable materials. Fittings should be made of black iron. All parts and surfaces must withstand a minimum of 250 pounds per square inch (psi) of pressure. Containers used to store anhydrous ammonia must be painted white or silver to reflect the heat of the sun away from control tank temperatures and pressure.

Daily system checks and routine maintenance are a must. A regularly scheduled replacement program of valves and hoses is recommended. Leaks in the system must receive immediate attention. Dents, gouges, and cracks must be repaired by qualified service representatives. Certified welders must be hired for repairs that require welding.

Equipment markings must warn users and bystanders of the hazards of anhydrous ammonia. The labels, markings, and safety signs include:

- Anhydrous ammonia labeling in 4-inch letters on the side and rear of the tank
- Inhalation hazard labeling required by the federal Department of Labor that must appear as 3-inch-high lettering on both sides of the tank

- ◊ Nonflammable gas placard with the number 1005 (identification number for anhydrous ammonia) must appear on both sides and both ends of the tank
- ◊ SMV emblem displayed on the rear of the tank
- ◊ Valves labeled by color or legend as vapor valves (Safety Yellow color) or liquid valve (Omaha Orange color); lettering must be at least 2 inches in height and within 12 inches of the valves

An estimated 80 percent of NH3 injuries and fatalities result from a lack of knowledge or training.

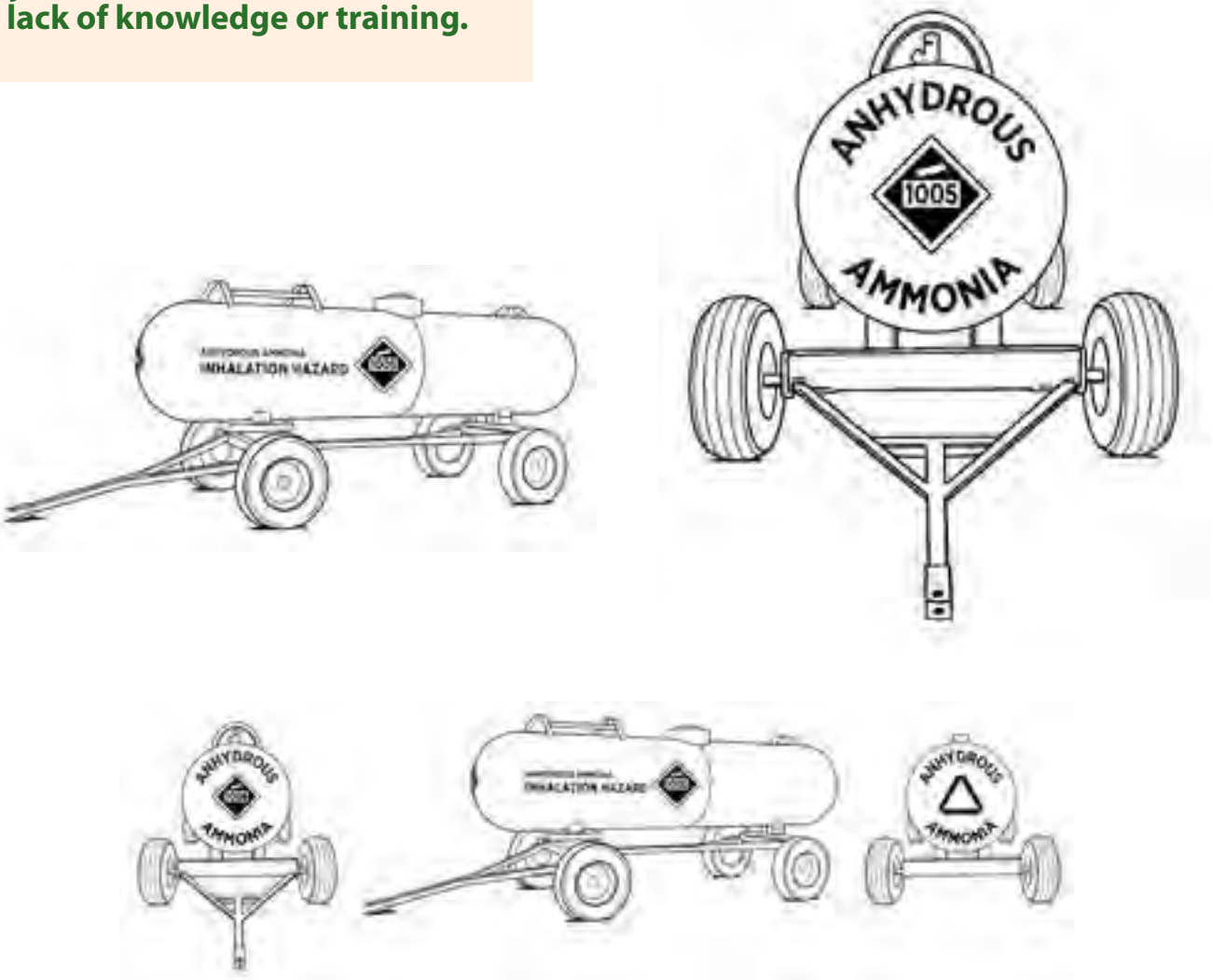

Figure 3.12.b. Anhydrous ammonia tanks must be plainly marked on all surfaces as containing an inhalation hazard. Such markings provide the message that this material is deadly. Illustrations by Andy Mylin

Anhydrous Ammonia Safety Precautions

Anhydrous ammonia is a deadly material. It can kill or incapacitate a person quickly. Constant attention to safety must be part of working with this material. Follow these safe practices:

- ◊ Use the correct personal protective equipment (a face shield or splash-proof goggles, rubber gloves, and heavy-duty long-sleeved shirts and pants are recommended).
- ◊ At least 5 gallons of clean, fresh water is required to be carried with each vehicle transporting anhydrous ammonia (exposure from spills or splashes will require at least a 15-minute flushing with water to dilute the anhydrous ammonia).
- ◊ Operators who are working directly with the NH3 should carry a squeeze bottle of water in their immediate possession to treat exposure.
- ◊ Remove contaminated clothing, which can become frozen to the skin (NH3 works as a cooling gas in the air).
- ◊ The operator should be trained in system components and how they operate.
- ◊ Daily safety inspections are necessary.
- ◊ All labels, markings, and safety signs must be in place and clear for visibility.
- ◊ Highway towing speeds should be reduced to less than 25 mph to decrease the risk of upsets or damage.
- ◊ Safety chains must be used for highway transport.
- ◊ Use a qualified service person to repair the tank, valves, fittings, and hoses.
- ◊ Keep untrained people away from the anhydrous ammonia tanks and equipment.

The same safe practices are to be followed if anhydrous ammonia is to be injected into corn silage as it is blown into the silo. Anhydrous ammonia is a valuable crop nutrient and feed additive if handled safely.

Workers should carry a small squirt bottle of water as they work with anhydrous ammonia.

Safety Activities

1. Use the website of the Department of Labor (**www.dol.gov**) or your state's Department of Transportation to locate information on hazardous materials placards. Print a copy of the various placards that are found on trucks hauling materials through your community.
2. Practice flushing the eyes with water for 15 minutes to prepare yourself for spills or splashes of any chemicals that could contact your eyes. Is there a water temperature that is best recommended? What source of water is best recommended?
3. Conduct a survey of local farmers to determine how many use anhydrous ammonia. Present the results at your 4-H club, FFA meeting, or mentor.
4. Research the possibility of purchasing small squeeze water bottles to use for eye flushing. Make these bottles available to local farmers along with a brochure on anhydrous ammonia safety.
5. Write a letter to local fire service groups informing them of the dangers of anhydrous ammonia. Ask them if they have the necessary equipment to work with local farmers who may need their emergency services.

Chemicals Used on Farms

Learning Goal

- Identify chemicals used in agriculture
- Handle chemicals safety

Related Task Sheets

- 1.2.1: Hazardous Occupations Order in Agriculture
- 1.2.4: Agricultural Worker Protection Standard
- 2.1: Injuries Involving Youth
- 2.4: Age-Appropriate Tasks
- 3.3: Respiratory Hazards
- 3.3.1: Respiratory Protection
- 3.4: Working with Livestock
- 3.5: Agricultural Pesticides
- 3.7: Fire Safety
- 3.7.1: Fire Prevention and Control

Introduction

Not all chemicals used on a farm are pesticides. Pesticides are chemicals that kill pests. Youth under the age of 18 who are not immediate family members employed by agricultural establishments are not permitted to work with restricted-use pesticides. Chances are high that you will be exposed to some chemicals that are not regulated under pesticide laws.

This task sheet discusses chemicals found on farms and working with these chemicals safely.

Chemicals on Farms

Many types of chemical materials are used on the farm. This task sheet will not identify every chemical but will focus on common areas on the farm that may use chemicals. Every year new products are added to the list.

The beginning farm worker 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. The milking process involves working with cattle and cleaning facilities and equipment, including milk pipelines. The animal treatment area may expose the worker to disinfectants and animal medications. Livestock center chores may range from baby pig care to feeding and care of beef steers. Field crop work may involve handling fertilizer and lime. Farm shop work finds a young worker cleaning parts and servicing equipment.

Dairy Farm

Dairy farm work involves using cleaners and sanitizers. Acid rinses, alkaline compounds, chlorine, and iodine materials are commonly found on farms. These can damage skin and produce toxic fumes.

The animal treatment area of a dairy farm has potentially hazardous materials. 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.

Livestock Center

Livestock center work parallels the work of the dairy industry. Animal medications are mixed into the animals' drinking water. Foot bath chemicals are mixed to treat foot health problems.

Field Crop

Field crop work, with the exception of pesticide application, will be assigned to most young workers. Hauling fertilizer and lime is a dusty chore. Those particulates can create respiratory health risks and skin irritation.

Farm Equipment

Farm equipment becomes greasy and covered with dirt. Degreasers and solvents may be needed to clean the parts. Hydrosulfuric acid will be encountered while servicing a battery (see Task Sheet 4.6.2). These materials are also hazardous.

Do you know what the chemicals you are handling can do to your body?

Figure 3.13.a. Farmstead chemicals are not pesticides. Animal medicines, fuels, paints, and solvents are also chemicals. Illustration by Jeff Mathison

Animals and Chemicals

Working with dairy, livestock, and small animals often requires the use of a variety of chemical products. Animals must be kept clean and healthy. Equipment used with animals must be disinfected. Unhealthy animals must be treated.

Young farm workers may handle a variety of chemical products. Disinfectants are used with livestock to reduce infectious organisms. These products may be applied to the animal directly by the worker. The material may be diluted with water and applied by way of foot baths.

Direct application of chemical formulations to the animal can be done by sanitary wipes or dust application. Udders and teats of the dairy cow 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 with 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 or one farm to another. Weigh scales and head locks are treated with disinfectants and may be applied with pressure-washing equipment. Livestock tools, such as dehorning and castration equipment, must be sterilized after each use.

Many animal medications or pharmaceuticals are also agricultural chemicals. Dairy and livestock must be treated for disease or vaccinated to prevent disease. Injections also supplement nutritional needs of the animal. The young farm worker will often be trained to assist with these injections.

Safe work habits will prevent you from unnecessary exposure to the active ingredients in these products. Follow these safety points:

- Read and understand product labels as well as Safety Data Sheets to ensure safe handling of the chemical.
- 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 accepting animal care tasks.

Young farm workers are often assigned to work with animal cleaning and sanitation products.

Figure 3.13.b. Dairy facilities require the use of a variety of cleaners, degreasers, and sanitizers to meet milk inspection standards. Credit: Penn State Extension Ag Safety Team

Lime and Fertilizer

Fertilizer and lime are necessary for plant growth. Fertilizer provides the plant with food elements like 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.

Fertilizer is a hygroscopic material. This means that it attracts moisture. As it pulls moisture from the skin, eyes, nose, or mouth, tissues can blister and burn. Exposure occurs when fertilizer is being handled. Operator exposure is increased when you are unprotected.

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.

Wear long-sleeved shirts, 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. There are many chemicals used for maintenance and repair tasks. The chemicals 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 can be fatal if swallowed. Antifreeze poisons a person who has swallowed it.

Caustic materials burn skin tissues quickly. Battery acid burns skins and clothes. Solvents can dry the skin and cause irritation.

Flammable materials pose a risk for explosion or ignition, which may combust rapidly. Petroleum products and cleaning solvents are Class B fuels for fire sources (see Task Sheets 3.7 and 3.7.1).

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 those areas of confusion

Special Note

Shop rags also pose a hazard. The rags may be soaked in toxic material from wiping up an area. The rags could be soaked in caustic material, such as battery acid, or they could contain flammable materials. Rags can expose the worker to hazardous materials and should be disposed of after use to prevent fires.

Young farm workers are often assigned to clean equipment and move crop supplies.

Figure 3.13.c. Spills can pose slip and fall hazards. Credit: Association of Equipment Manufacturers (symbol) and Penn State Extension Ag Safety Team (photo)

Safety Activities

1. Visit a dairy farm, horse farm, beef farm, or swine facility. With the owner's permission, make a list of all the farmstead chemicals that you can find. Do not include pesticides.
2. If you are studying this material in a group, have the group make a list of farmstead chemicals that they have used on their farm or a farm where they are working.
3. Are dairy cleansers, sanitizers, and medicines covered by the Worker Protection Standard? Refer to Task Sheet 1.2.4 or use the Internet to search for "Worker Protection Standard."
4. Research foot rot in livestock and how it's controlled.
5. Find out what procedures a local farmer would use to clean up an oil, antifreeze, or fuel spill. Write the procedures in outline form.
6. Define these terms:
   a. sanitize
   b. acid compound
   c. alkaline compound
   d. hydrated lime

References

Association of Equipment Manufacturers Pictorial Database, **www.aem.org/safety-and-technical/safety/pictorial-database**.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

HOSTA Task Sheet 3.14

Animal- and Insect-Acquired Infections and Related Hazards

Learning Goal

- Understand the hazards to the worker from zoonotic diseases, wildlife, and insects
- Understand the risks of bacterial, protozoan fungal, and viral infections

Related Task Sheets

- 1.1: The Work Environment
- 2.11: First Aid and Rescue
- 3.4: Working with Livestock

Introduction

Working outdoors on a farm may expose youth to hazards from animal- or insect-transmitted diseases. Diseases can be transferred to humans through contact with infected animals or insects. Farm workers may potentially encounter animals that present unique hazards, such as venomous snakes or insects.

This task sheet discusses livestock- and wildlife-related hazards.

Zoonoses

"Zoonoses" is the term for diseases that can be transmitted between vertebrate animals and humans. These diseases can be transferred in several ways.

Direct Transmission

Direct transmission occurs through contact with an animal, its products, such as manure, urine, or placenta, or consumption of products, such as raw meat or raw milk. An animal bite may also transmit a disease. Disease-causing organisms and disease-carrying insects can be found in and on these products.

Animal manure contains bacteria from the animal's digestive system. E. coli, a bacteria, is found in manure. This bacteria can cause intestinal disease, with nausea and general feelings of ill health.

Animal products such as meat and milk can carry microorganisms that can cause disease. Meat can be contaminated with 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 at risk for exposure to insects and ticks.

Infections of the animal's reproductive tract can be transmitted to people who assists with the birthing of calves, piglets, lambs, and foals. Sterile, disposable gloves should be worn to protect

against harmful organisms. Such 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.

Indirect Animal Contact

Soil, plants, and water can be contaminated by animal wastes. Surface water (streams and ponds), water wells, and reservoirs can be contaminated with animal waste. Avoid drinking such water to reduce your exposure to potential health risks.

Ringworm is an example of a zoonotic disease.

Figure 3.14.a. Cattle can transmit ringworm, rabies, and other microorganisms to humans. Credit: Michael Houtz, Penn State Extension

Stinging Insects and Venomous Snakes

Stinging Insects

Wasps, hornets, bees, other stinging and biting insects, and spiders and tarantulas are found throughout America. Many farm workers have been stung by one or more of these pests with various reactions.

Insect bites create health problems for some people. Allergic reaction to the sting or bite is one such reaction. Anaphylactic shock is caused by insect venom and is a serious medical emergency. Anaphylactic shock 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 be taken to emergency medical care immediately.

Venomous Snakes

Various species of venomous snakes 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 a snake.

Occasionally, a farm worker may encounter a snake that may strike. Farm work in seldomly used barns, along fences, and near woodlots can bring the worker into a surprise encounter with a snake. Quick identification of the snake as venomous versus harmless is necessary. Venomous snakes have an angular head with a pit in front of the eyes. If such a snake is encountered, take the following actions:

- ◊ 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, take the following steps to prevent the wound from becoming more serious:

- ◊ Allow 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 your movements carefully.

Insects and snakes are found in the fields and barns where farm employees work.

Figure 3.14.b. Stinging insects and venomous reptiles are found throughout the United States. Each geographic area may have its own set of insect and snake species that may be hazardous. Credit: Julian Avery, Penn State

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, skunks, bats, and foxes. Cats, cattle, and dogs can also become infected.

Rabid animals appear to be confused, paralyzed, excitable, and frothing from the mouth.

The best way to prevent rabies is to avoid animals that show strange behavior. Report such animals to your employer or parents.

If bitten by an animal that is suspected of having rabies, kill the animal if need be, handle the animal carcass with disposable gloves, and submit the animal for postmortem testing. A person who has been exposed to rabies will need medical treatment immediately.

Figure 3.14.c. Raccoons are common carriers of rabies. If you find these animals acting abnormally, be alert for the danger of a rabid animal bite.

Lyme Disease

Ticks often attach themselves to warm-blooded animals and feed on their blood. Their blood-filled bodies are commonly found on dogs and deer. These same ticks can also attach and feed on human blood.

Ticks are often found on people who have been walking in tick-infested areas. Adult ticks wait on host weed species and attach to warm-blooded hosts as they pass by.

The deer tick (blacklegged tick) is common in the northeastern United States. Deer ticks can be found on deer hunters who are processing the animals. Deer ticks may carry Lyme disease and must be removed immediately. Along the Pacific Coast, the western blacklegged tick spreads the disease.

Lyme disease, first reported in Lyme, Connecticut, has spread nationwide. It affects people who have been bitten by a deer tick but failed to notice the insect attached to their bodies. Generally, the Centers for Disease Control and Prevention indicate that a tick must be attached for 36 to 48 hours or longer before the disease can be transmitted. Lyme disease left untreated can cause a rash and flu-like symptoms followed by loss of coordination and memory, irregular heartbeat, and arthritis. However, Lyme disease is rarely fatal.

Lyme disease is preventable. These considerations will reduce the risk of Lyme disease exposure:

- ◊ Wear light-colored clothing when in infested areas to help you see the tick.
- ◊ Tuck pants into socks to keep ticks out.
- ◊ Treat clothing with an insect repellent approved for tick control before going into woods or fields.
- ◊ Avoid weedy, brushy areas that may harbor ticks.
- ◊ Check your body for ticks when returning home.

Lyme disease presents a concern, but it should not keep anyone from enjoying walking or working in the fields and woodlands or hunting and fishing.

If you suspect that you are infected with Lyme disease, consult a physician immediately. A second opinion may be needed as Lyme disease can be diagnosed as one of many other nervous system problems. Antibiotics are used to treat Lyme disease.

Deer ticks carry Lyme disease.

Figure 3.14.d. Deer harbor a tick that can carry Lyme disease. Hunters who bag a deer should take precautions to avoid becoming infected. Inspect your body after handling infected deer during processing.

Safety Activities

1. Use the website of your state land-grant university's entomology department to locate pictures of stinging insects. Make a collage of the insects that you have seen or have stung you. Place a label on the insect picture to identify it.
2. Interview 25 people to determine how many have had an allergic reaction to an insect sting. From the percentage of people calculated to be allergic, determine how many people that may be in the United States if the total population is estimated to be 300,000,000 people. How many people may have this allergic reaction? (This is not a scientific study.)
3. Word search. Draw a line through as many words about zoonotic diseases and their carriers as you can find. Words may be horizontal, vertical, diagonal, forward, and backward. Use these words: parasites, bacteria, ringworm, rabies, malaria, virus, snake, tick, insect, rat, bat.

R	A	B	C	B	T	A	M	O
I	R	D	R	A	T	I	A	Z
N	A	E	B	T	T	R	L	X
G	B	F	G	T	I	E	A	X
W	I	N	S	E	C	T	R	S
O	E	H	I	R	K	C	I	I
R	S	U	R	I	V	A	A	T
M	J	K	L	A	M	B	N	E
P	A	R	A	S	I	T	E	S

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4

Section Four
The Tractor

Agricultural Tractors

Learning Goals

- Describe how tractors vary in size, shape, and age
- Describe how tractors are designed for work

Related Task Sheet

- 4.2: Tractor Hazards

Introduction

In 1892 a man named John Froelich developed a successful tractor to power a grain thresher. By 1918 a PTO shaft was used to power equipment drawn behind the tractor. Before these time periods, farm work was done hand, horse, or huge stationary steam engines.

You will be operating a tractor designed to accomplish greater amounts of work than ever thought possible in the early 1900s. The speed, power, flexibility, adaptability, and handling ease of modern tractors is what makes them valuable and indispensable for modern-day farming. This task sheet describes agricultural tractors, with an emphasis on what tractors are designed to do.

Tractor Design

Tractors are versatile machines that come in many different designs or configurations. Some may have a narrow or wide wheelbase that may use wheels or tracks. Tractor propulsion systems can be rear-wheel drive (RWD), rear-wheel drive with front-wheel assist, four-wheel drive steer (4WD), or four-wheel drive articulating steering (4WDAS). Tractors built before 1976 had limited safety features integrated in their design.

Tractors used for purposes beyond the intended design may lead to machine failure and an injury or fatality. Many older and smaller tractors will not have a rollover protective structure (ROPS), while most new tractors will have a ROPS and seatbelt. It is important for young and inexperienced tractor drivers to become familiar with the controls and features of a tractor that they will be operating. Tractor operator stations are designed to fit most individuals. Most tractors will have some ergonomic features that you can adjust to position yourself adequately to reach and use the controls safely.

Ergonomics: the study of human abilities and limitations to improve people's interaction with products, systems, and environments.

Figure 4.1.a. Tractors come in all shapes and sizes. Credit: Michael Houtz, Penn State

Tractor Purposes

Tractors are designed to transmit power generated by the engine (power source) to complete work more efficiently. This is typically accomplished through hydraulic, electrical, or mechanical connections to implements or equipment. Tractors can serve as a remote power source or be directly connected to the equipment/implement.

Understanding that farm tractors are not recreational vehicles is very important. Tractors deserve your respect. "Hot rodding" and other improper use can lead to equipment failure and potentially an injury or fatality. Improper use or carelessness increases the risk to you or others, as well as damage to the tractor, implements, and other property.

Figure 4.1.b. Tractors should be used for their designed purpose. Credit: Michael Houtz, Penn State

Tractor Characteristics

- ◊ Adjustable wheel spacing
- ◊ Steering variations
- ◊ High-horsepower engine
- ◊ Transmission with many gear ranges for relatively low speeds
- ◊ Higher ground clearance
- ◊ Greater weight over traction wheels
- ◊ Individual brakes for each rear wheel
- ◊ Adjustable drawbar hitch
- ◊ Power controls to increase pulling power
- ◊ Potential to change wheel weights for ballast
- ◊ Hydraulic system for added power source
- ◊ PTO shaft to transfer power to towed machine
- ◊ Differential lock for added traction
- ◊ Fitted with a rollover protective structure (ROPS) or a falling object protective structure (FOPS)
- ◊ Equipped with an enclosed cab for operator comfort and safety

A tractor is designed to do work. Use the tractor only for this purpose!

Safety Activities

1. Take photos or video footage of tractors being used for four intended purposes. Make a display for your club or classroom or employee lunchroom where you work.
2. Collect newspaper and magazine articles on farm tractor safety. Share the main points of the articles with your classmates.
3. Locate a farmer in your community who has been injured with a tractor or farm machine and see if they will discuss the incident with you.
4. Use the Internet to find information on tractor safety. Find articles that describe people injured by a tractor because they were not using it for its designed purpose.
5. Do a survey of tractors at area farms or on an equipment dealer's lot and record how many tractors (a) have a tricycle or wide front end; (b) have a ROPS with seatbelt; (c) have wheels or a track; and (d) if it has wheels, is it a two-wheel, four-wheel, or an articulated tractor? Also record the engine horsepower and tractor age.

Reference

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Tractor Hazards

Learning Goal

◊ Recognize and avoid those hazardous situations that can result in exposure to overturns, runovers, PTO entanglements, and safety deficiencies in older tractors

Related Task Sheets

◊ 2.3: Reaction Time
◊ 3.1: Mechanical Hazards
◊ 4.1: Agricultural Tractors
◊ 4.12: Tractor Stability
◊ 4.13: Using the Tractor Safely
◊ 5.41: Using PTO Implements

Introduction

Tractors are a primary source of work-related and non-work-related injuries on farms. Nationally, the tractor-related incidents are the leading cause of death for farmers and farmworkers. Injuries occur for a variety of reasons and in a number of different ways. This task sheet will describe types of tractor hazards and the nature and severity of injuries associated with using farm tractors.

Injury Events

There are several hazards associated with tractor operation. A hazard is defined as any source of potential damage, harm, or adverse health effects to something or someone. Tractor hazards are commonly associated with the following four injury event categories:

1. Overturns or rollovers
2. Runovers or backovers
3. Entanglements
4. Roadway collisions with other vehicles

Each of these is discussed briefly in this task sheet. Other task sheets will cover some of these topics in more detail. Older tractors often present numerous hazards that increase the risk of an injury event.

Overturn or Rollover

Tractor overturns or rollovers are major injury events and account for the most farm-work fatalities. Fatalities occur when tractors overturn either sideways or rearward. There are dozens of examples of tractor turnover situations. Most are preventable if operators follow good safe tractor operation practices. Some common unsafe practices that increase the risk 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 slope that is too steep
◊ Turning a tractor sharply with a front-end loader raised high

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

A rollover protective structure (ROPS) is a structurally engineered frame or enclosure designed to protect the operator, such as an enclosed cab. Combined with a seatbelt, the ROPS provides a zone of protection around the operator in the event of a tractor overturn. The operator cannot stay in the zone of protection if the seatbelt is not fastened. Remember, a ROPS can protect you from injury, but it cannot keep the tractor from overturning in the first place. This explains the importance of operating a tractor safely even if the tractor has a ROPS.

Figure 4.2.a. Tractor overturns can occur with high-speed sharp turns. Avoid sudden sharp movements in all tractor work. Illustrations by Jeff Mathison

Follow this rule: One seat on a tractor means one rider only—the operator. Keep all others away!

Figure 4.2.b. Tractor runovers have claimed many lives. Extra riders can slip from the tractor and be crushed before the operator can stop. Credit: Penn State Extension Ag Safety Team

Runover or Back over

Four common **unsafe** practices are associated with most tractor runover incidents.

The first to note is when a passenger (extra rider) on the tractor falls off. Extra rider incidents happen because there is only one safe place for a person to be on a tractor, and that is in the operator's seat. Some new, larger tractors have an extra seat for temporary instructional purposes, but only if the tractor has an enclosed ROPS cab. The tractors that most young and inexperienced operators drive will have only one seat—the operator's seat. Standing on the tractor drawbar, axle housing, side links of three-point hitches, rear-wheel fenders, and the area immediately around the operator's seat are common locations unsafely occupied by extra riders. Extra riders rarely keep a tight handgrip on the tractor. Thus, they can be easily thrown from the tractor.

The second runover incident to discuss involves the tractor operator either falling off the tractor as it is operating or being knocked out of the seat by a low-hanging tree branch or other obstacle. This happens most often on older tractors that do not have a ROPS and have an older seat that has no arm or back rest (often

called pan seats). A person can more easily lose their balance and be knocked off or bounced out of a pan seat.

The third runover incident to discuss is when 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, and the tractor moves unexpectedly. This may happen during the hitching and unhitching of equipment. Shut off the tractor before dismounting for any reason.

The fourth type of runover incident involves a person who is on the ground near a tractor. Often a tractor operator will try to start a tractor from the ground while the tractor is in gear. This usually involves an older tractor that can be started in gear or when an operator attempts to bypass a newer tractor's safe start-up design. Bypass starting hazards are discussed in more detail in Task Sheet 4.8.

Additionally, people may be backed over when the equipment is placed in reverse for hitching or moving materials. Small children, often under the age of five, are sometimes run over by a tractor (and equipment) as it is moved around the farmstead. Often, the tractor operator is unaware that the child is near the tractor. A loud noise, such as the start-up of a tractor, is often attractive to a young child, who may run toward it as it starts or begins to move.

Entanglement

Entanglement in rotating machine components and equipment such as the tractor power take-off (PTO) shaft is another major injury event. The PTO shaft transfers power from the tractor to PTO-powered machinery. The PTO normally turns between 540 and 1,000 revolutions per minute. At this rate, the stub is turning from 9 to 17 times per second. This is much faster than a human being can react if they are caught and pulled into or around the PTO shaft. A person can have an arm or leg wrapped around a PTO stub shaft before they know 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. Tractors should have guards and shields to protect the operator and helpers.

Roadway Collisions

Several factors contribute to motor vehicle and farm tractor collisions. Many farmers own or lease land not connected to the main farm, requiring them to drive equipment on public roadways to reach the field.

Farm tractors and other self-propelled farm equipment are slow-moving vehicles. This typically means they operate at speeds of 25 mph or less. Newer tractors and equipment are now capable of traveling at 35 to 40 mph. These high-speed tractors require additional marking to identify them to motorists. More will be discussed on lighting and marking in Task Sheets 4.14 and 4.14.1.

Another factor is that tractors are often on the roads during the day when lighting conditions can make it difficult for motorists, who are traveling faster, to react to the tractor until it is too late. The tractor and trailing equipment are often struck while making a left-hand turn.

As farms have increased in size, so has the equipment. You will commonly see a six-row planter, but now it is no surprise to see 24- or even 36-row planters being moved along roadways into the field.

Rural roads are often narrow with limited shoulder access, which creates a hazardous condition when traffic is at higher volumes. Research has shown that higher traffic volumes significantly increase the risk of a collision. This research indicated that as road and shoulder width increased, the likelihood of a collision decreased.

Review state and local laws to make sure you're in compliance when transporting agricultural machinery and tractors on public roadways. It is important to stay alert while transporting equipment.

Figure 4.2.c. Power take-off stub and PTO shaft must be properly guarded to prevent entanglements. Locate the PTO area on every tractor you operate. Check whether or not that area is safely guarded. Credit: Michael Houtz, Penn State

PTO shafts kill or injure countless victims. Some of these victims may live in your community.

Older Tractors

Older tractors deserve a special discussion when it comes to tractor hazards. Many farm tractors still used for work today may be 30 to 40 years old or older. These older tractors are often less safe to operate because they do not have modern safety features and some parts of the older tractor may not have been maintained in good working condition. Below is a list of reasons why older tractors may be less safe to operate:

- ◊ Lack of ROPS and seatbelt
- ◊ A seat without arm and back rests (pan seat)
- ◊ 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

Young and inexperienced workers may be given older tractors to operate in many cases. These older tractors are sometimes designed for tasks such as raking hay, hauling wagons, and mowing fields or pastures. Young and inexperienced operators should be given newer tractors to operate when possible.

Figure 4.2.d. This tractor does not have a ROPS or seatbelt. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Match the safety term with the appropriate definition (some choices may be used more than once).

   _____ A. Overturn
   _____ B. Runover
   _____ C. PTO entanglement
   _____ D. Older tractor deficiency

   1. High lift carried in raised position in transit
   2. Tractor operator leaves the seat before shutting off the tractor and falls off.
   3. Bypass starting
   4. PTO stub shaft missing
   5. Driving too close to ditch embankment
   6. A friend is helping to drop the hitch pin

2. Text a message to your best friend explaining why you won't let them ride on the fender of the tractor to go to the field to help you make hay.
3. Explain how people are run over when they choose to bypass the ignition switch to start the tractor engine.
4. Contact a tractor salesperson or mechanic to learn more about the hazards of bypass starting a tractor engine.

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Agricultural Youth Work Guidelines Tractor Operation Chart

Learning Goal

◊ Review safety recommendations for matching tractor size and tasks with the age of the tractor operator

Related Task Sheets

◊ 1.2: Safety and Health Regulations
◊ 2.1: Injuries Involving Youth
◊ 2.4: Age-Appropriate Tasks

Introduction

Farm families often provide much of the labor for the operation of the farm. Children may start early by helping with farm work as a means of learning responsibility and contributing to the productivity of the farm. Tractor operation can come at an early age for many farm youth because tractors are a large part of how farm work is done. Tractor work can range from simple to complex.

This task sheet presents a Tractor Operation Chart as a guide to appropriate tractor work for young tractor operators.

Youth and Tractors

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

Several hazards can arise during the course of these and other jobs that involve tractor use. Many times, the larger the tractor, the more complex the operation of that tractor. Additionally, large and complex equipment may be attached to and powered by the tractor.

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

Agricultural Youth Work Guidelines Tractor Operations Chart

(*formerly North American Guidelines for Children's Agricultural Tasks [NAGCAT]*)

Farm injury prevention specialists from the United States and Canada have developed consensus opinion that a guide to tractor operations according to age-group is a way of matching youthful capabilities with tractor operation jobs. The Tractor Operations Chart is presented on the following page. You can use this chart to:

- ◊ See if you have been doing jobs with the size tractor that matches your age
- ◊ Guide an employer in determining what they can reasonably expect a person of your age to do with various types and sizes of tractors

It is common for youth to be overconfident in their ability to react safely to new or unexpected hazard situations involving tractors.

Figure 4.3.a. Youth should never operate a tractor without a ROPS and seatbelt. Credit: Jeff Mathison

Are your skills and age matched to the appropriate tractor and tasks?

Tractor Operation Chart

Guidelines for Safe Operation of Tractor

- **Tractors have**
  - o Wide front ends
  - o Roll Over Protective Structure (ROPS) and seatbelt
  - o All safety features in place
- **Youth**
  - o Perform pre-operational check with adult
  - o Can reach all controls while wearing seatbelt
  - o Does not have extra riders on the tractor
  - o Operates tractor only in daylight and during good weather
  - o Avoids steep slopes and driving near ditches, trees and fences

Refer to the specific guideline for recommended supervision

Increased complexity of job (rows, from least to most complex)

	Size of Tractor			
	LAWN & GARDEN less than 20hp	**SMALL** 20hp to 70hp	**MEDIUM/LARGE** more than 70hp	**ARTICULATED**
OPERATING A FARM TRACTOR (no equipment attached)	14 - 15 years	14 - 15 years	14 - 15 years	16+ years
TRAILED IMPLEMENTS	14 - 15 years	14 - 15 years	14 - 15 years	16+ years
3-POINT IMPLEMENTS	14 - 15 years	14 - 15 years	14 - 15 years	16+ years
REMOTE HYDRAULICS	14 - 15 years	14 - 15 years	14 - 15 years	16+ years
PTO-POWERED IMPLEMENTS	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 OVERSIZE OR OVERWEIGHT LOAD	Due to increased hazard and complexity, these jobs should **not** be assigned to children.			
HITCHING TRACTOR TO MOVE STUCK / IMMOVABLE OBJECTS				
SIMULTANEOUS USE OF MULTIPLE VEHICLES				
ADDITIONAL PERSONS ON A TRAILING IMPLEMENT				
PESTICIDE OR ANHYDROUS AMMONIA APPLICATION*				

* follow state/province laws

Tractor Instrument Panel

Learning Goals

- Understand the instruments and gauges used to monitor the tractor's operation and performance
- Make operating decisions based on the information and gauges provided to the operator

Related Task Sheets

- 4.6: Preventative Maintenance and Pre-operation Checks
- 4.6.1: Fuel, Oil, and Coolant Levels
- 4.6.2: Lead Acid Batteries

Introduction

Instruments, or gauges, on the tractor control panel tell the driver about the operating conditions within and around the tractor. All tractor drivers should know what instruments are available to indicate that the tractor is operating properly.

When tractor systems are not working properly, continued operation may cause costly repairs and possible injury.

This task sheet will identify and explain instruments and gauges commonly found on tractors. Using tractor owners' manuals and obtaining the help of an experienced tractor operator will help you learn the information in this task sheet.

Instruments and Gauges

Instruments can include warning lights, analog gauges, computer digital displays, buzzers, or standard gauges. It is important for the beginning operator to develop the habit of regularly checking the instrument panel. Check the gauges:

- At start-up
- At regular intervals during operation
- When changes occur in the normal sounds of operation

Abnormal gauge readings, plus changes in operating sounds, indicate that there is a problem. You should immediately stop the engine in a safe place and seek help from the owner or an experienced operator.

Instruments you will use may include the following, among others:

- 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 to operating the tractor safely as well as avoiding damage to the tractor. Other gauges may be found on the tractor you operate. Be sure to understand the meaning of all instruments, gauges, and warnings before operating a tractor.

Figure 4.4.a. The modern tractor instrument panel can be as complex as the cockpit controls of a jet airliner. Credit: Michael Houtz, Penn State

Learn which warning lights, gauges, and digital displays are on your tractor.

Figure 4.4.b. Indicator lights, standard gauges, computerized digital displays, and buzzers show operating conditions. Credit: Penn State Extension Ag Safety Team

Tachometer (Engine Speed Indicator)

Tachometers show revolutions per minute (RPM). Engine RPM must be matched to the job being done. Incorrect RPM can lead to:

- Engine damage
- Driveline and PTO damage
- Hazardous situations

Low engine speed while in a higher gear and beginning to pull a heavy load can stall the engine. High engine speed with a low gear while attached to a heavy load can also create enough torque (rotational force) to tip the tractor backward. Accelerating quickly with a heavy load going up a slope can cause the tractor to rear up and tip backward.

Engine RPMs 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 was already under load (for example, a plugged hay baler).

Follow the manufacturer's recommendations for engine speed selection. Tachometers may be gauge type or have a digital display.

Engine speed must match the work being done to be safe and avoid engine and driveline damage.

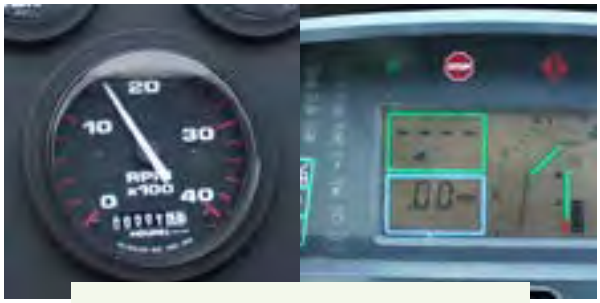


Figure 4.4.c. Check the manufacturer's RPM recommendations for various jobs to be done. Credit: Penn State Extension Ag Safety Team

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 problem. The engine may not start the next time due to a low battery.

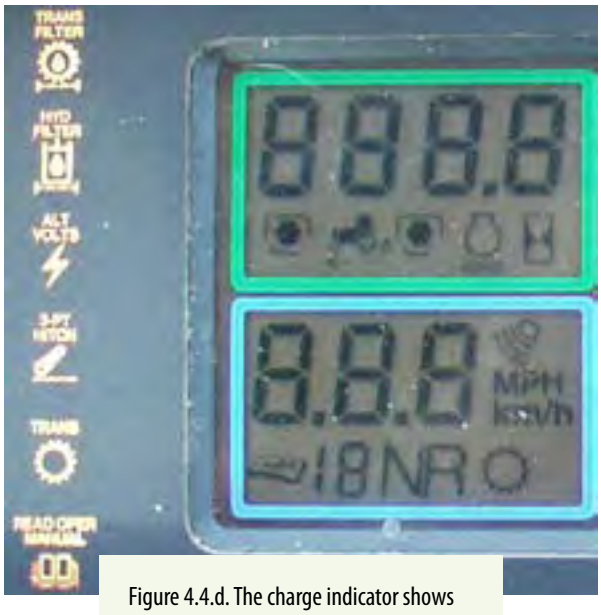


Figure 4.4.d. The charge indicator shows whether the alternator or generator is charging the battery properly. Credit: Penn State Extension Ag Safety Teams

Oil Pressure Indicator (Oil Light or Gauge)

This indicator is important to the long life of an engine. If oil pressure falls because of an oil leak or low oil levels, the light or gauge shows you must stop the engine immediately. Never operate the engine with low oil pressure or levels. Oil lubricates the internal parts of the engine and prevents major repair expenses.

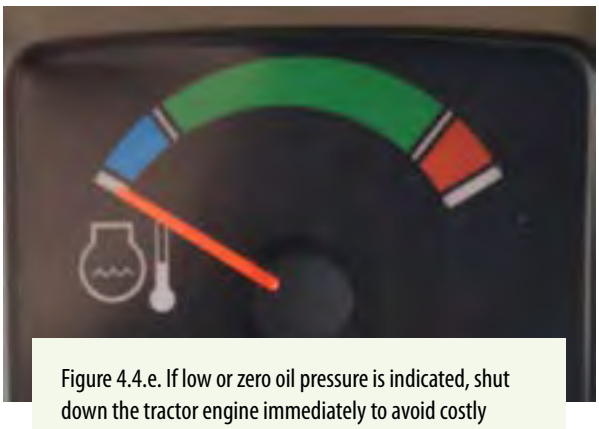


Figure 4.4.e. If low or zero oil pressure is indicated, shut down the tractor engine immediately to avoid costly engine rebuilds. Credit: Jeff Mathison

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, and then check for the problem.

Figure 4.4.f. Wait until the engine is cool to remove the radiator cap. Illustration by Andy Mylin

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

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 bleeding of air from the fuel lines in order to be able to start the tractor again.

Other Gauges

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

Safety Activities

Questions

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. When pulling a heavy load of hay up a hill, which gear/RPM (engine speed) combination should you use?
   a. fifth gear/high RPM
   b. lower gear with medium RPM
   c. highest gear with lowest RPM
4. The letters RPM represent:
   a. ground speed measurement
   b. oil pressure measurement
   c. engine speed measurement

Activities

1. Demonstrate to your teacher how many hours of use have been placed on the tractor by showing the hour meter reading for that tractor.
2. Demonstrate to your teacher how to scroll through the various computer digital readouts to show engine RPM, engine temperature, and hours of use information on that tractor.

Reference

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Tractor Controls

Learning Goals

- Identify tractor controls by their color coding
- Identify what action will result when a control is moved in a particular direction

Related Task Sheets

- 4.5.1: Engine Stop Controls
- 4.5.2: Ground Motion Controls
- 4.5.3: Engagement Controls

Fig 4.5.a. Know where each control is located and what it controls. Color codes will help you learn the function of each control. Credit: Jeff Mathison

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

Introduction

To help tractor drivers identify controls and use them correctly, many tractor manufacturers use the same color code for specific tractor controls. The directions that you move or actuate the controls have 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 irregularly colored control knob.

Moving a control that is not color-coded may not result in the expected operation.

This task sheet will identify the four main groups of tractor controls, their colors, and their direction of movement. Each group of controls will be discussed in more detail in their own task sheet.

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 below. Commit this color code to memory. You will use this information 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 that older tractors may not use these colors, or you may not be able to see them. If the tractor you need to use does not have color controls, take time to learn about the controls on that tractor.

Moving Controls

As a general rule, controls will function as follows:

- 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 as the control is moved.
- 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 you for lifting.
- A PTO is usually engaged when pulled up or pushed forward.

Figure. 4.5.b. Learn what the different colors mean on tractors. Credit: Penn State Extension Ag Safety Team

You are responsible for many controls. Know the use of each one.

Safety Activities

1. Matching color with function. Place the letter of the correct color next to the control function.

   _____ Engage PTO

   _____ Lift a High-Lift Bucket

   _____ Throttle Up

   _____ Stop the Diesel Engine

   A. Red

   B. Orange

   C. Yellow

   D. Black

2. Identify as many specific controls as you can on one or more tractors, and group them by control function.
3. What will happen if you pull an orange-colored control in order to stop the tractor engine?

Reference

American Society of Agricultural and Biological Engineers. ASABE/ISO 15077:2008 OCT2008 (R2013) Tractors and Self-Propelled Machinery for Agriculture—Operator Controls—Actuating Forces, Displacement, Location and Method of Operation. St. Joseph, MI.

Engine Stop Controls

Learning Goals

- Identify tractor engine stop controls used on modern tractors by their color
- Identify the results when an engine stop control is moved in a particular direction

Related Task Sheet

- 4.5: Tractor Controls

Introduction

Before getting started with using a tractor, we must answer the question of how do you stop the engine. This is important when putting the equipment away for the day or in the event of an emergency. Tractors can be a little confusing when it comes to controls for stopping the engine.

Manufacturers have used the same color for certain controls to help drivers identify controls and use them correctly. This task sheet discusses the "stop engine" control.

The Color Red

Red is the color code for the single-purpose "stop engine" control. Whether it is a gasoline engine tractor, a diesel engine tractor, or an alternative fuel engine, the color red indicates a stop engine function.

- Gasoline engine: red letters on key switch
- Diesel engine: red fuel shutoff switch

Remember, most diesel engines are shut off with the fuel shutoff switch, not the ignition key.

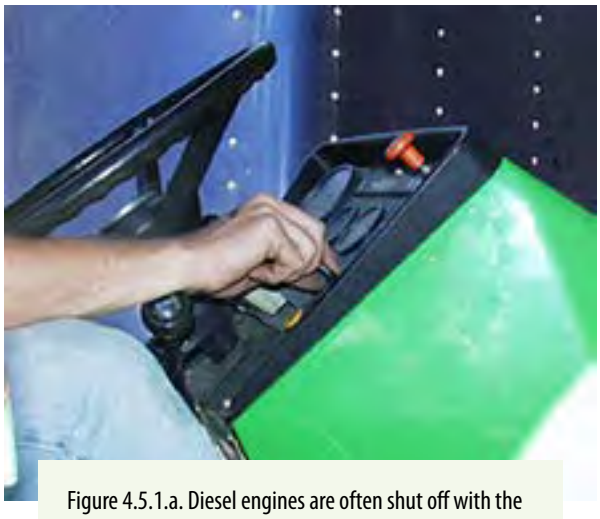


Figure 4.5.1.a. Diesel engines are often shut off with the fuel shutoff switch, not the ignition key. Credit: Penn State Extension Ag Safety Team

A red control knob means "stop engine."

Some Rules for "Red"

Here are a few more points to remember for the red engine stop control. If a mechanical push-pull fuel switch is used, it must:

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

Key switch controls turn counterclockwise to stop the engine. Some newer diesel engines are also stopped simply by turning the key counterclockwise to the off position.

Pictorial Study

Figure 4.5.1.b. Diesel engines are often stopped by shutting off the fuel flow from the fuel pump. Credit: Penn State Extension Ag Safety Team

Figure 4.5.1.c. Key switch on lower left of older tractor. Credit: Penn State Extension Ag Safety Team

Figure 4.5.1.d. Older tractors may not use the color red to indicate the stop engine control. Credit: Penn State Extension Ag Safety Team

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

Safety Activities

1. Compare the ignition switch and stop engine control methods of diesel and gasoline engine tractors by tracing the wiring of each.
2. Find the oldest tractor model you can in your community and determine if color coding would indicate how to stop the engine. Record the following information:

Tractor model: _____

Approximate age of tractor: _____

Color-coded stop control: Yes No

References

American Society of Agricultural and Biological Engineers. ANSI/ASABE, EP443.1 Color Coding of Hand Controls. St. Joseph, MI.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Ground Motion Controls

Learning Goals

- ◊ Identify tractor ground motion controls by the orange color coding
- ◊ Identify what action results when a ground motion control is moved in a particular direction

Related Task Sheet

- ◊ 4.5: Tractor Controls

Introduction

After you are familiar with starting and stopping the tractor engine, you are ready to put the tractor in motion. For many years, tractor manufacturers have used the same color for certain controls to help drivers identify and use them correctly. This task sheet discusses the "ground motion" controls used to put the tractor into motion.

The Color Orange

Orange is the color code for tractor ground motion controls. Ground motion controls include:

- ◊ Engine speed
- ◊ Transmission controls
- ◊ Parking brake or park-lock
- ◊ Independent emergency brakes
- ◊ Differential lock

You can easily become confused if you are not familiar with the tractor. Do not hesitate to ask for a demonstration of the controls and job you will be doing.

Figure 4.5.2.a. Ground motion controls include transmission controls, park-lock, and gear-shift levers. Credit: Penn State Extension Ag Safety Team

An orange control knob shows you where to control ground motion.

Some Rules for "Orange"

Here are more important points to remember for orange ground motion controls:

- ◊ Engine speed controls 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.
- ◊ Brake locks may be a mechanical lock on the drive train versus a lock on the axle.

Pictorial Study

Figure 4.5.2.b. The foot throttle on the tractor is orange in color. Credit: Jeff Mathison

Figure 4.5.2.c. Brakes are locked together; the orange lever is for setting the brakes on this tractor. Credit: Penn State Extension Ag Safety Team

Figure 4.5.2.d. Older tractors may have the paint removed or were made before ground motion controls were color coded. Credit: Penn State Extension Ag Safety Team

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

Safety Activities

1. Ask the farmer/owner if you can inspect all the tractors on a farm. Note the orange color-coded controls. What does each control do? Make a comparison of how older model tractor controls are identified for ease of recognition compared with newer model tractors.
2. Identify as many ground motion controls as you can on several different tractors. Compare their locations and the direction in which they are moved.

References

American Society of Agricultural and Biological Engineers. ANSI/ASABE, EP443.1 Color Coding of Hand Controls. St. Joseph, MI.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Power Engagement Controls

Learning Goals

- Identify tractor power-engagement controls on modern tractors by their color coding
- Identify what action results when a power-engagement control is moved in a particular direction

Related Task Sheet

- 4.5: Tractor Controls

Introduction

Operating a tractor will sometimes require the use of towed or hitched equipment that utilizes the tractor as a power source. Balers or manure spreaders often require power from the tractor. Being able to start and stop these machines is important. Many tractors will have PTO controls for this function.

Tractor manufacturers color code controls to help operators identify and use them correctly. This task sheet discusses the "power engagement" control.

The Color Yellow

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
- Cutterheads
- Feed rolls
- Elevators
- Winches
- Unloading augers

You can easily become confused if you are unfamiliar with a tractor. A quick review of the owner's manual will help identify controls and their function. Do not hesitate to ask for a demonstration of the job you will be doing.

Figure 4.5.3.a. Yellow color-coded controls engage accessories. This is often done through the PTO. Credit: Penn State Extension Ag Safety Team

Some Rules for "Yellow"

Here are a few more points to remember for yellow power-engagement controls. These controls can be knobs, toggle or rocker switches, levers, or pedals.

1. PTO controls are designed to move to the rear downward to disengage the PTO.
2. Horizontal-mounted rocker switches use the right side to begin normal machine operation.
3. 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.

Pictorial Study

Figure 4.5.3.b. Most control levers are right-side mounted. Credit: Penn State Extension Ag Safety Team

Figure 4.5.3.c. Some control levers may be left-side mounted. Credit: Penn State Extension Ag Safety Team

Figure 4.5.3.d. Rocker arm switches may be used. Credit: Michael Houtz, Penn State

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

Safety Activities

1. Ask the farmer/owner if you can inspect all the tractors on the farm. Note the yellow color-coded controls. What does each control do? Make a comparison of how older model tractor controls are identified for ease of recognition when compared with newer model tractors.
2. Identify as many power-engagement controls as you can on several different tractors and compare their locations and the directions in which they move.

References

American Society of Agricultural and Biological Engineers. ANSI/ASABE, EP443.1 Color Coding of Hand Controls. St. Joseph, MI.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Positioning and Adjusting Controls

Learning Goals

- ◊ Identify tractor positioning and adjusting controls on modern tractors by their color coding
- ◊ Identify what action will result when a position/adjustment control is moved in a particular direction

Related Task Sheet

- ◊ 4.5: Tractor Controls

Introduction

The number of knobs and levers used to operate today's tractors and farm machinery can seem overwhelming. To lift or move attachments such as a loader bucket you must know how to use the proper controls to get the task completed safely.

For many years, tractor manufacturers have used the same color for certain controls to help drivers identify and use them correctly. This task sheet discusses the "positioning and adjusting" controls that are associated with tractor work accessories.

The Color Black

Black is the color code for the many controls that 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
- ◊ Cab comforts (fans, radio, etc.)

You can easily become confused if you are unfamiliar with a tractor. Do not hesitate to ask for a demonstration of the controls to use for the job you will be doing.

A black control knob means "position or adjust."

Figure 4.5.4.a. Black controls adjust accessory position and control electrical components. Credit: Michael Houtz, Penn State

Some Rules for "Black"

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

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

Pictorial Study

Figure 4.5.4.b. High lift controls are color-coded black. Credit: Penn State Extension Ag Safety Team

Figure 4.5.4.c. The light control switch is a black rocker switch. Credit: Jeff Mathison

Figure 4.5.4.d. There are many seat adjustments shown here. Seat positioning and adjusting is coded with black knobs. Credit: Penn State Ag Safety Team and Michael Houtz, Penn State

Figure 4.5.4.e. Many older tractors may not have color-coded controls. Refer to the owner's manual and ask for help. Credit: Penn State Extension Ag Safety Team

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

Safety Activities

1. Ask a farmer/owner if you can inspect all the tractors on the farm. Note the black color-coded controls. What does each control do? Make a comparison of how older model tractor controls are identified for ease of recognition compared with newer model tractors.
2. Obtain the operator's manual for a tractor and read the instructions for setting the three-point hitch to control the depth of plows or scraper blades.

References

American Society of Agricultural and Biological Engineers. ANSI/ASABE, EP443.1 Color Coding of Hand Controls. St. Joseph, MI.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Location and Movement of Tractor Controls

Learning Goals

- Identify the location of major operating controls on tractors
- Move a tractor's major operating controls to obtain a desired function

Related Task Sheets

- 4.5: Tractor Controls
- 4.5.1: Engine Stop Controls
- 4.5.2: Ground Motion Controls
- 4.5.3: Power Engagement Controls
- 4.5.4: Positioning and Adjusting Controls

Figure 4.5.5.a. Tractor controls are placed in specific locations so that operators do not have to search for them. Credit: Michael Houtz, Penn State

Introduction

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. For example, when mowing hay with a 12-foot-wide mower-conditioner and approaching an uphill grade, the operator may need to adjust ground speed (ground motion control). If the operator notices an object in the field during mowing, the mower head may also need to be raised to avoid damaging the knife guards and knife sections (machine positioning control).

This task sheet will identify several important tractor controls and their direction of movement.

Controls allow you to safely operate the tractor.

Control Devices and Functions

Tractor operator's manuals help tractor drivers identify controls and use them correctly. For example, specific controls can be located using the operator's manual. You must be able to locate specific controls from the operator's seat as well as know the specific direction to obtain

the desired effect of the control. Familiarize yourself with the color coding for main groups of controls, but keep in mind that many older tractors may have controls or directions of movements that are not the same as those of newer tractors.

Three common types of control flow 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, and control electrical and hydraulic flow. Computer functions are also part of the control panel on modern tractors. Older tractors may have controls placed in various locations. How the controls are used may be entirely different from tractor to tractor. Always refer to the operator's manual.

Movement and Location of Controls

The same location and direction of motion for controls makes it easier to operate the tractor safely and efficiently. Engineering standards provide uniformity between tractor manufacturers for the location and direction of motion for tractor controls. 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 each tractor you operate. Consult the tractor owner to be sure you know where a control is located and what happens when you move a control. Do this before operating the tractor.

Brake Control

Foot brake pedals are engaged by pressing the pedal forward or downward with the operator's right foot. 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 clutch operated by a foot pedal must be located on the left side of the operator. The pedal is moved downward or forward to disengage the clutch. A hand-operated clutch is disengage by moving the control rearward or toward the operator.

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

Power take-off (PTO) control

A hand-operated PTO control can be located on either side and is disengaged by moving the control rearward or downward. This is called an independent PTO clutch. Older tractors may use a "live" PTO, which uses the foot-operated clutch pedal to disengage both the transmission and the PTO.

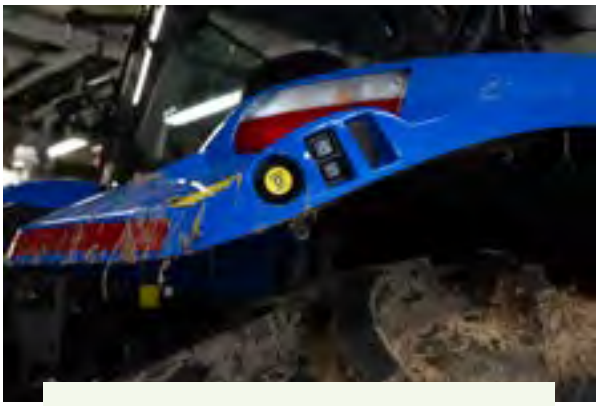


Figure 4.5.5.a.(a). Power take-off (PTO) control, exterior. Credit: Michael Houtz, Penn State

Figure 4.5.5.a.(b). Power take-off (PTO) control, interior. Credit: Michael Houtz, Penn State

Figure 4.5.5.b. Brake control. Credit: Michael Houtz, Penn State

Figure 4.5.5.c. Clutch control. Credit: Michael Houtz, Penn State

Figure 4.5.5.d. Engine speed control. Credit: Michael Houtz, Penn State

Engine Speed Control

This control is located on the right side of the operator. If the hand-operated control moves parallel to the tractor seat, the direction of motion must be forward or upward to increase engine speed. If the hand-operated control moves parallel to the rim of the steering wheel, move the control rearward or downward to increase engine's RPMs. If a foot-operated control is provided, it must be on the right side and moved forward and/or downward to increase speed.

A control on an older tractor may not do what you expect it to do.

Ground Speed Control

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

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 to increase speed. To go in reverse and 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 the operator's foot is taken off the pedal.

Differential Lock Control

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

Engine Stop Control

A key switch must be rotated counterclockwise to stop the engine. A mechanical pull-push control must be within 6 inches of the key switch and pulled to stop the engine. Engine stop and ground speed controls that are combined into a single lever must move in the same direction to first slow ground speed and then stop the engine.

Lift Controls for Implements or Attachments

Lift controls must be located 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 4.5.5.f. Ground speed control.
Credit: Michael Houtz, Penn State

Figure 4.5.5.g. Differential lock control.
Credit: Michael Houtz, Penn State

Figure 4.5.5.h. Engine stop control.
Credit: Michael Houtz, Penn State

Figure 4.5.5.i. Lift controls for implements or attachments. Credit: Michael Houtz, Penn State

Safety Activities

1. Visit area farms or equipment dealers and review with the farmers or dealers how the major controls operate. Make a record of which ones follow ASAE standards for location and direction of motion.
2. Solve this word search puzzle on tractor controls and color coding. Words to use:

   BLACK CONTROL

   GEARSHIFT

   RED ENGINE STOP

   BRAKES

   LIFT CONTROL THROTTLE

   DIFFERENTIAL FOOT PEDAL

   ORANGE CONTROL PTO

   YELLOW CONTROL

L E R C W W T U J S P B U U S J S J V X Q V C J J
O Z N A R E D E N G I N E S T O P I Z T P V Y B Y
Q Q N D F X T F W N K O O T D V V L E E B Y O Q O
A P J I A K K S X N V A U O C E Q A Z Y F S R S Q
P C V F Q N G T H Y E T A Y L X V Z V K L I O B W
W L I F T C O N T R O L T H R O T T L E Q S H Z J
V Z B E Y J O X H S N V S T M H A D I Z I B C T K
J H D R T N O I N Y C R J P Z M G I F S G S V J Q
A V O E R D Q R B Y E B J I D R M B J J X P K S R
F G V N P Z L V A K S L S V M F F K X H Z Q Y B G
B I P T I R F I U N X D L H G C X Q V Q D Z T R J
L M J I E J I U D U G S Q O F N K R I W G H A A P
A U Z A H Q N Y G D E E B U W P M J R H B L G K D
C W P L Y H F H G V C O C M V C L U B O Y E E E R
K X W F Y A Y P A D I L M O Z K O L Z Z U W A S Z
C Q V O D Z C O O E K L X X N S D N F T A N R J Q
O Y K O E N P Z K M E F H Z X T E A T O A J S S M
N N R T Q L R V C J H W S L T D R C G R G R H L H
T H G P H P P B I W H Y K T X J W O S U O Z I A E
R N G E T R A P G O V K V O H X A S L R B L F Q J
O Y Q D E J H G I J G B C X H P M O S P L B T X A
L T L A F M B V S N Y P Q I E H I W O L T V T M J
F E A L V S S B S T D K V R R M A O N F Q O X G D
H R Q Q F P E W X I G P W D G N S L D W B U C Q K
K D X L L Z M K P Z P W X A Q W H P A F I R Z C U

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Smith, D. W. *Tractor Standards That Promote Safety*. Texas A&M AgriLIFE Extension. **https://agsafety.tamu.edu/educational-material/**.

Tractor Operation Symbols

Tractor operation symbols provide quick information regarding operating functions and malfunctions.

Learning Goals

- Recognize the messages that tractor operation symbols are conveying in normal tractor use
- Recognize the messages that tractor operation symbols are conveying in order to react to possible malfunctions

Related Task Sheets

- 2.8: Hazard Warning Signs
- 4.4: Tractor Instrument Panel
- 4.5: Tractor Controls

Introduction

Operational symbols were designed to promote and improve tractor and equipment use and safety in the agricultural workplace. Operational symbols are pictures displayed in a standard way to show tractor and equipment operating functions with minimal use of words.

This task sheet discusses farm tractor operation symbols that operators should recognize and understand. Always refer to the owner's manuals to learn more about these symbols for the farm tractors you will operate.

Farm Tractor Operation Symbols

Symbols are designed to draw your attention to operating functions and alert you to malfunctions. These symbols may also be found on other types of agricultural, construction, and industrial equipment. Owner's manuals detail operating symbols of particular importance to your tractor or machine. You may also need to use the accessories on a tractor. Operation symbols will be found on the equipment as well as on the tractor.

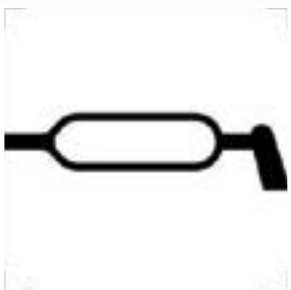
Symbols quickly help a person recognize a function or malfunction. Learn what each symbol communicates. This information can help you prepare for work or respond to a malfunction. During tractor operation, these symbols will indicate what to do or what is happening.

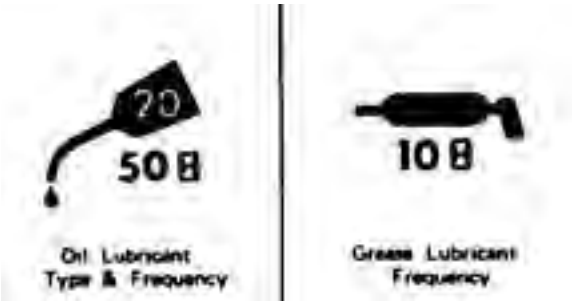
This symbol represents diesel fuel. Be sure of which fuel you are putting into the tank (note the capital letter "D"). From this pictorial, can you identify the type of fuel pump and the type of fuel supplied.

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.

This symbol is an ALERT for a malfunction. Alert symbols usually are found in conjunction with another symbol.

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.

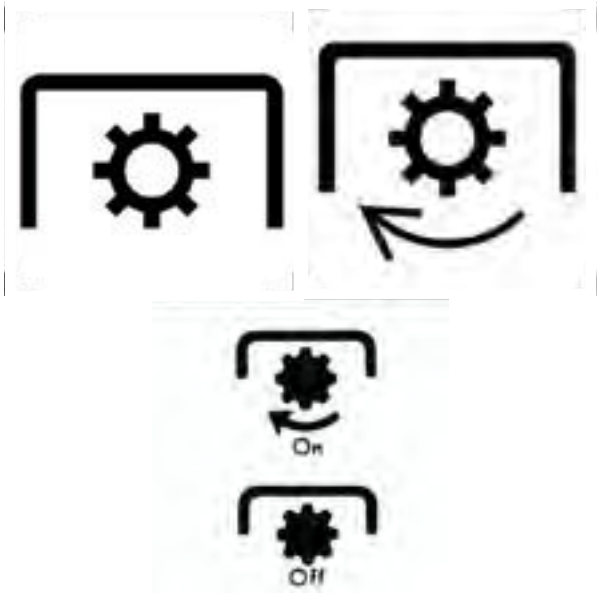




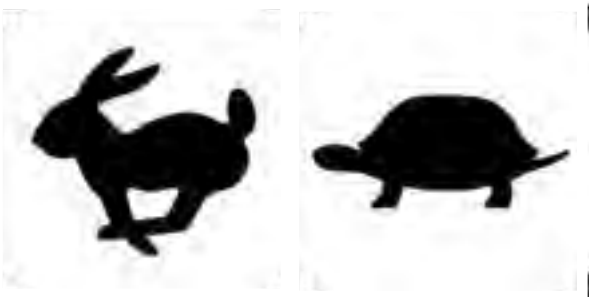
Universal symbols provide operating information. The oil can symbol may be used to indicate frequency of oil changes and the SAE number of oil to use. This picture would represent a SAE 20 oil changed at 50 hours. The grease-gun-shaped object shows a grease point and how often to apply the lubricant.

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.

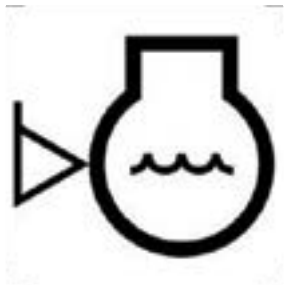
This symbol will show you what the engine speed is.



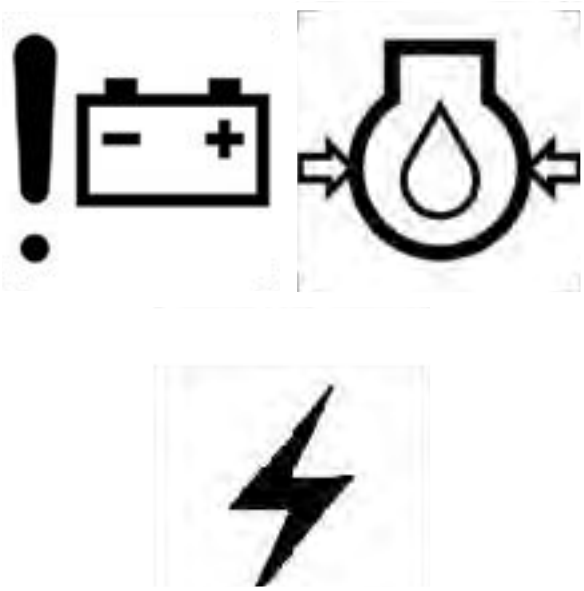
The PTO symbol indicates an engaged/ disengaged function.



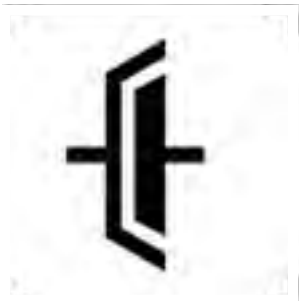
The throttle symbol depicts a slow turtle and fast rabbit to represent speed control selection.



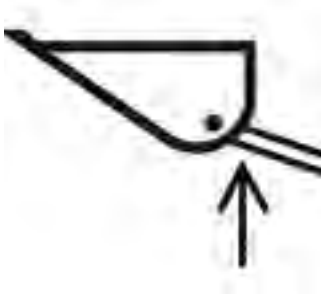
This symbol indicates or alerts the operator to the engine coolant level.



The engine oil pressure and battery symbols are used to draw your attention to malfunctions during operations. An oil pressure gauge or any other indicator that illuminates is an indication to stop the engine immediately. The operator should address the problem as soon as safely possible.

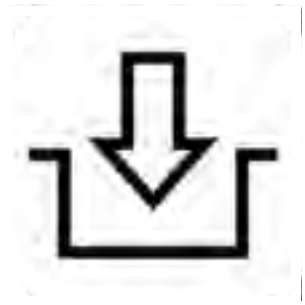


This symbol indicates the operational status of the clutch.

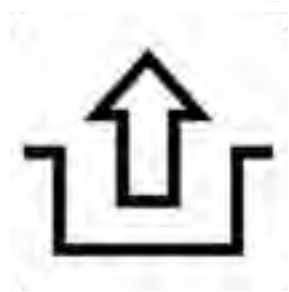


This symbol indicates that the resulting operation will raise the high-lift bucket. This is a positioning and adjusting control symbol.

This symbol indicates that the resulting operation will tilt the high-lift bucket to the rear.



This symbol identifies the control that effects the engagement of two machine parts or activation of a mechanical function. Recall that engagement controls are yellow in color. Remote power operation occurs.



This symbol identifies the control that effects the disengagement of two machine parts or the deactivation of a mechanical function.

Always refer to the operator's manual for the symbols used with the tractor in operation. You should study them for future reference. Older tractors will not have operation symbols. It is important to know how to identify malfunctions using the instrument gauges.

Make an effort to learn all of the symbols. Owner's manuals can be helpful.

Safety Activities

1. List the top five operating symbols you would locate and respond to before you start a tractor. Explain why you think these five symbols are important. Discuss this with your instructor and peers.
2. You are assigned to rake hay in a field one mile from the farm shop. The engine oil pressure light comes on. Draw the symbol that alerts you to this malfunction.
3. In problem 2, what should be done with the tractor when the problem is observed?
   a. Drive it back to the farm shop
   b. Continue to rake hay
   c. Shut it down immediately
   d. Let the tractor idle while you use the cell phone to notify the owner of the tractor
4. A tractor you are using begins to show a low-battery charge problem. What should you do?
   a. Return to the shop area without finishing to rake the hay
   b. Shut it down immediately
   c. Return to the shop area after finishing to rake the hay
   d. None of the above
5. In the space below, draw an operation symbol that would indicate engine failure or malfunction. Check your drawing using a tractor owner's manual.

Reference

Farm and Ranch Safety Management. John Deere Publishing, 2009.

American Society of Agricultural and Biological Engineers, ANSI/ASABE, S304 Graphic Symbols for Operator Controls and Displays on Agricultural Equipment, St. Joseph, MI

Preventive Maintenance and Pre-Operation Checks

Learning Goal

◊ To conduct pre-operation checks on a daily basis to reduce repair costs and downtime

Related Task Sheets

◊ 4.6.1: Fuel, Oil, and Coolant Levels
◊ 4.6.2: Lead Acid Batteries
◊ 4.6.5: Tire and Wheel Condition
◊ 4.6.6: The Operator Platform

Introduction

John is a part-time farmer. Two years ago, he purchased a small utility tractor with backhoe and scraper blade for $12,000. He wanted to push snow, clean the barn, and do odd jobs on his property. While driving his tractor down the road, the engine overheated, began to make noise, lost power, and shut down. A neighbor stopped by and John asked, "What could be the problem?" He was already pouring water in the radiator. "Could it be the hydrostatic transmission?" he asked as he checked that dipstick.

The neighbor suggested the engine oil, but John didn't know where to find that dipstick, which turned out to be hidden by the high-lift arms. The dipstick registered no oil at all.

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

New tractors are expensive. Be sure to complete a pre-operation checklist before starting the engine.

Pre-Operation Checks

A good operator uses a daily checklist to inspect items and systems before starting the tractor. This is often called a pre-operation checklist. Many drivers write down what needs to be inspected and then check the items off the list as they examine them.

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
◊ SMV emblem
◊ Fluid leaks
◊ Operators platform/steps
◊ Seat/adjustment
◊ Seat belt
◊ Fire extinguisher
◊ Lighting/flashers
◊ Visibility from operator's seat

Some Practical Hints

Here are several things to look for as you perform 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 your vision
- ◊ Headlights or warning lights with broken bulbs or glass
- ◊ An SMV emblem that is faded or distorted in either color or shape
- ◊ A fire extinguisher with a pressure gauge in the "recharge" range
- ◊ Several tools or supplies on the operator platform

Don't start the engine until you have completed the "walk-around" inspection and are sure all systems are ready to work for you.

Safe Starts

Some newer utility or lawn tractors may have safety start systems. If so, the owner should also have in good working order one or both of the following items:

- ◊ 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

Good operators take responsibility for the tractors they operate.

Safety Activities

1. Make a chart of maintenance items to be done on your tractor. Use the following format or develop your own chart. If you have a computer, make a spreadsheet or database project to help with maintenance records.

Tractor Maintenance Log

Date	Item Checked	Problem Found	Corrective Action

2. Help someone change the oil and oil filter on a tractor.
3. Help someone change an air filter on a tractor.
4. Call a tractor dealer/service center and ask for any maintenance charts or record forms that they can send to you.
5. Memorize the "pre-op" checklist and recite it as you conduct a pre-operation inspection for your class or an interested adult.
6. Math Problem: You forgot to check the engine oil in the tractor before starting. When the oil light came on, you continued working. Now the engine must be rebuilt to the amount of $5,000. This is the only tractor that can pull the forage harvester and chop 40 acres per day for the next 5 days. An estimated nutrient loss value of $10 per acre will occur due to the delay in harvest. Calculate the dollar loss to the producer.

Reference

Farm and Ranch Safety Management. John Deere Publishing, 2009.

HOSTA Task Sheet 4.6.1

Fuel, Oil, and Coolant Levels

Learning Goals

- ◊ Understand how to check fuel levels of common engines (alternative fuels excluded here)
- ◊ Safely check coolant levels of liquid cooled engines
- ◊ Correctly check oil levels of any engine

Related Task Sheet

- ◊ 4.4: Tractor Instrument Panel

Introduction

A tractor is a huge investment to make farm work more efficient. Even a mid-size tractor may cost $40,000 or more.

The tractor must be kept in top operating condition. Downtime for engine and tractor repairs are costly. An engine rebuild may cost over $5,000 in parts and labor. A crop in the field may be lost because of harvest delays. Crop losses can lead to increased costs from purchasing replacement feeds or protein supplements.

Tractor and equipment pre-operation checks can help reduce the likelihood a costly breakdown. A damaged engine or running out of fuel is no excuse for the skilled operator.

This task sheet discusses the importance of checking the fluid levels of the fuel, coolant, and oil before you touch the tractor ignition switch. Developing this habit will help you understand that the tractor engine is ready for field work.

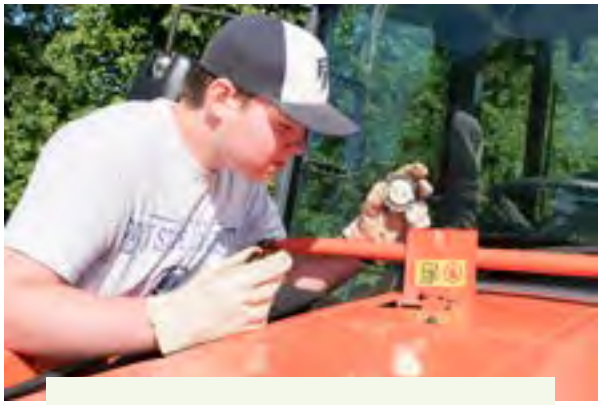


Fig. 4.6.1.a. Before driving the tractor to the field, check for the possibility of an empty fuel tank. If you run out of fuel during a workday, you are causing downtime losses. Credit: Jeff Mathison

What to Do

Fig. 4.6.1.b. Check the fuel level. Credit: Penn State Extension Ag Safety Team

Fig. 4.6.1.c. Check the oil level. Credit: Penn State Extension Ag Safety Team

Fig. 4.6.1.d. Check the coolant level with the engine cold. Credit: Penn State Extension Ag Safety Team

Why You Should Check Fuel, Coolant, and Oil Levels

Fuel

Check the fuel level before leaving the barnyard or maintenance area. You cannot assume that someone else has done this job. Failure to check the fuel level may result in lost field time. It may also result in the need to mechanically bleed air from diesel fuel lines in some older tractors. Be sure you use the correct fuel type to fill fuel tanks. The wrong fuel will cause damage and require additional repairs.

Oil

Oil bathes metal surfaces to prevent the heat of friction from damaging the moving parts. Low engine oil allows engine parts to overheat, expands them, and "seizes" the engine. Overfilling the engine oil results in oil seal damage. Use the oil dipstick daily to prevent engine damage.

Coolant

Coolant fluid (water and antifreeze) carries engine heat away from the engine. Air flowing across the radiator then reduces the coolant temperature. Lack of coolant causes overheating of the engine. 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.

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

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

Safety Activities

1. Park the tractor at the farthest field from the barn and time your walk back to the farm shop or fuel area. This is wasted time or downtime when cropping work could be completed.
2. Call a tractor dealer's service department to ask about the cost to rebuild a tractor engine damaged from lack of oil. Provide this information to your class and instructor.
3. Using a hydrometer (a device used to measure the specific gravity of coolant or antifreeze to determine the level at which the liquid would freeze), test engine coolant for level of temperature protection that coolant would provide.
4. Explain the meaning of the term "oil viscosity."
5. Describe the difference between diesel fuel and gasoline. How does the storage of these fuels differ?

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Lead Acid Batteries

Learning Goals

- ◊ Identify battery parts and functions
- ◊ Become familiar with hazards of lead acid batteries
- ◊ Use safe practices when working with and caring for batteries

Related Task Sheets

- ◊ 4.6.3: Using a Battery Charger
- ◊ 4.6.4: Using Jumper Cables

Introduction

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

Battery electrical current results from a chemical reaction. Many batteries are considered lead acid. These batteries use lead plates immersed in a mixture of sulfuric acid and distilled water. This chemical solution, called electrolyte, can burn your 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 power to the starting motor (starter).

Correct battery care and use will provide countless starts of the tractor engine in a safe manner. This task sheet discusses battery construction, hazards, care, and safety.

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

Parts of a Battery

- ◊ Battery case: container to hold the battery acid solution and electrical storage plates
- ◊ Battery plate: holds electrical charges (+) and (-)
- ◊ Terminals: connected to the storage plates and become the connecting points for battery cables leading to the starter (+) and the ground (-)

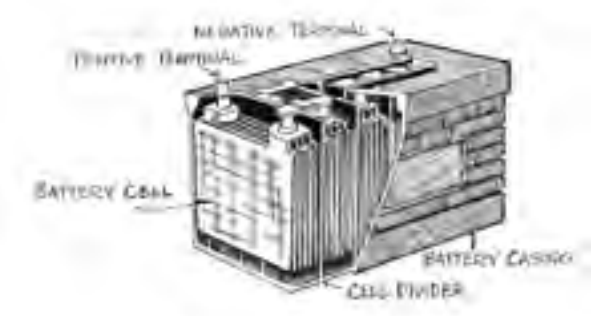


Fig. 4.6.2.a. Battery construction. Inside the battery case are plates, which hold the electrical charges (+) and (-) and sulfuric acid-water mix. Also included the battery case are the connections to the battery terminals (posts). These terminals also extend outside the battery case. Battery cables connect the posts to the starter motor and a grounding surface. Illustration by Jeff Mathison

Battery Hazards

Hazard	Definition	Safety Precautions
Explosions	Battery acid produces hydrogen gas, which is explosive. A spark can lead to fire (dust, chaff, etc., around the battery) or explosion of hydrogen gas from the battery itself.	Use splash-proof safety goggles and rubber gloves. Keep the battery posts clean of corrosion.
Chemical Burns	The electrolyte solution in a battery is caustic to the skin and eyes and can burn holes through clothing.	Check fluid level often to prevent gas buildup. Maintenance of fluid levels reduces the space in a battery where gases can accumulate.
Electrical Shock	The electrical charge of a battery may be only 12 to 26 volts, but with the effects of the ignition coil on spark ignition, engines may produce voltages in the range of 100,000 volts. You can receive 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 Practices

1. Check battery fluid levels often. Low electrolyte levels increase the space where hydrogen gas can accumulate.
2. 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.
3. When removing a battery for replacement or bench work, remove the ground cable first.
4. When replacing a battery, install the ground cable last.
5. 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.
6. Keep battery terminals clean of corrosion for best electrical contact. Prevent the corroded material from getting on your skin or in your eyes.
7. If you spill battery acid on your skin, flush it off with water immediately.
8. If you splash battery acid in your eyes, flush with warm water for at least 15 minutes. Seek medical attention.

Safety Activities

1. 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 the help of an adult supervisor, clean the battery terminals of a corroded battery by removing the battery cables (ground cable first and positive or "hot" cable last). 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. Search the Internet to learn more about batteries. One source is **www.ACDelco.com**.

References

Battery Safety for Trainers and Supervisors. Agricultural Tailgate Safety Training, Agricultural Safety and Health Program, Ohio State University Extension. 2018.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Using a Battery Charger

Learning Goals

- ◊ Safely use a battery charger to charge a weak battery
- ◊ Use all safety procedures to prevent chemical burn, explosion or fire, and electrical shock

Related Task Sheets

- ◊ 4.6.2: Lead Acid Batteries
- ◊ 4.6.4: Using Jumper Cables

Introduction

Batteries that are not cared for properly or nearing the end of their useful life expectancy can be expected to fail. Many times, that failure will come at the onset of cold weather when higher current demands are placed on the battery.

Batteries will lose their charge when not used for extended time periods. Often the battery can be recharged to prolong its usefulness. Some chargers can also be used to jumpstart a battery.

This section discusses the correct procedure to charge a 6- or 12-volt lead-acid battery. For other voltage situations, consult the battery manufacturer's recommendations or the operator's manual for your tractor.

Battery Charging Procedures

Follow the steps below for a tractor that has a negative ground (most tractors do; but if you are not sure, have it checked).

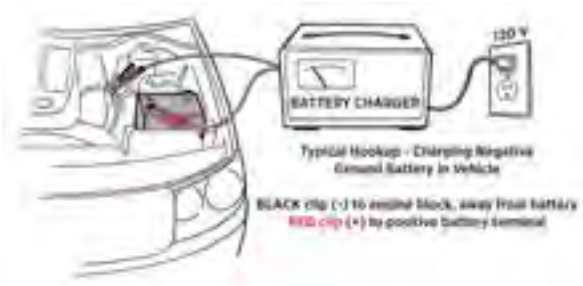


Figure 4.6.3.a. Battery polarity. A battery has two poles or posts. The positive battery post is usually marked POS, P, or (+) and is larger than the negative post, which is usually marked NEG, N, or (-). Illustration by Andy Mylin

Tools you will need:

- ◊ Safety glasses
- ◊ Approved battery charger
- ◊ Wrenches to remove battery cables
- ◊ Battery terminal cleaner
- ◊ Rubber gloves

Figure 4.6.3b. Tools you will need to change a battery. Credit: Penn State Extension Ag Safety Team

Battery charging: the red cable goes to the POSITIVE (+) battery terminal, and the black cable goes to the NEGATIVE (-) battery terminal.

Step 1. Connecting the Charger to the Battery

- ◊ If the charger has a switch with an OFF position, it must be set to OFF.
- ◊ The AC power cord to the charger must be unplugged.
- ◊ Connect the POSITIVE (red) charger clip to the POSITIVE post of the battery.
- ◊ Next connect the NEGATIVE (black) charger clip to the frame or engine block away from the battery.

Caution: Do not connect clip to carburetor, fuel lines, or sheet metal body parts. Connect to a heavy-gauge metal part of the frame or engine block. This prevents sparks at the battery terminals, which can ignite hydrogen gas produced by the battery during a rapid charging situation.

Step 2. Turning the Charger On

- ◊ If equipped with a voltage switch, set the switch to the appropriate voltage for the battery.
- ◊ If equipped with a rate switch, set the switch for the desired charge rate.
- ◊ If equipped with a timer, set the timer to the charge time desired.
- ◊ Plug the AC cord into a grounded outlet. Stand away from the battery.
- ◊ Do not touch the charger clips when the charger is on.
- ◊ The charger should now be on and the ammeter showing the rate at which the battery is charging.
- ◊ The initial rate may be somewhat higher or lower than the charger's nameplate rating depending on battery condition and AC voltage at the outlet.

Step 3. Turning the Charger Off:

- ◊ Set the selector switch to OFF.
- ◊ Unplug the AC power cord from the outlet.
- ◊ Remove black charger clip connected to frame. If charging a battery outside of a vehicle, remove clip connected away from battery.
- ◊ Remove clip connected to positive battery post.

Connect the battery charger using the correct procedure to avoid sparks and possible explosions.

Safety Activities

1. With the help of an adult mentor, practice using a battery charger to safely charge a battery.
2. Identify all the ways a battery's posts may be labeled to show the positive and negative battery poles.

References

Compact Equipment: Safety Management for Landscapers, Grounds-Care Businesses and Golf Courses. John Deere Publishing, 2001.

Preventive Maintenance. Fundamentals of Machine Operation Series. John Deere Publishing, 2013.

HOSTA Task Sheet 4.6.4

Using Jumper Cables

Learning Goals

- ◊ Safely use booster cables to jumpstart a weak battery
- ◊ Use all safety procedures to prevent chemical burn, explosion or fire, and electrical

Related Task Sheets

- ◊ 4.6.2: Lead Acid Batteries
- ◊ 4.6.3: Using a Battery Charger

Figure 4.6.4.a. 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). Illustration by Jeff Mathison

Introduction

Batteries can also lose a charge when not used for extended time periods. Using a booster battery and jumper (booster) cables to start the tractor may be necessary.

This task sheet discusses the procedures to safely jumpstart a 6- or 12-volt battery to start the engine. Always consult the owner's manual for your tractor or the battery for manufacturer recommendations.

Jumpstarting 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

Tools you will need:

- ◊ Safety glasses
- ◊ Approved booster cables of 4-, 6-, or 8-gauge wire (lighter wire [higher wire gauge number] will not carry enough current to jumpstart the battery)
- ◊ Wrenches to remove battery cables
- ◊ Battery terminal cleaner
- ◊ Booster battery usually from another tractor or vehicle
- ◊ Rubber gloves

Jumpstarting an engine with a drained battery is the same whether the drained battery is in a tractor, truck, or car. Normally, you will use another tractor, truck, or car battery to try and start the tractor 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 jumpstarting 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 your 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 that everyone is standing away from the vehicles.
7. Start the tractor with the booster battery.
8. Allow 1 to 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 that you put them 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 moments 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 yourself.

Safety Activities

1. With the help of an adult mentor, use jumper cables to practice starting a tractor.
2. Review owner's manuals for procedures on jumpstarting a farm tractor.

References

Compact Equipment: Safety Management for Landscapers, Grounds-Care Businesses and Golf Courses. John Deere Publishing, 2001.

Preventive Maintenance. Fundamentals of Machine Operation Series. John Deere Publishing, 2013.

HOSTA Task Sheet 4.6.5

Tire and Wheel Condition

Learning Goal

◊ Identify faulty tire and wheel situations and take corrective action to remedy the problem

Related Task Sheet

◊ 4.6: Preventive Maintenance and Pre-Operation Checks

Introduction

Tractors are traction machines! Better traction comes from good tires.

Tractor tires can cost several hundred dollars each. Estimates show that tractor tire repair and replacement comprise nearly 30 percent of the total repair costs during a tractor's lifetime. Operators must be responsible and protect this valuable traction component.

This task sheet discusses tractor tire and wheel conditions for safe tractor operation.

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 objects.
◊ Make tire repairs promptly.

Figure 4.6.5.a. Tractor tire components may include the tire, the rim, an inner tube with a valve, and, many times, a liquid solution filling the inner tube to serve as a liquid ballast. Credit: Jeff Mathison

Tire and Wheel Hazards

Tractors are not built for high speed. High speeds on paved roads reduce tire life. Unpaved roads can do the same and also increase the chance for large stones to damage the tire.

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, which can cut tires. Be alert for objects that can damage tires.

Improper use can ruin tires. Turning too tight and gouging the tire into towed equipment leads to cut tires. Most tractors don't have shock absorbers, so the tire must absorb all ground shocks. Tire sidewall breaks can occur when objects are impacted.

Some rear tractor tires are filled with a liquid solution to add weight to the tractor to improve traction.

Tire and Wheel Defects

Fig. 4.6.5.b. Worn treads and dry rot make for poor traction and risk for downtime due to a blowout. Credit: Jeff Mathison

Fig. 4.6.5.c. Damaged rims from careless use may cause damaged tire beads and flat tires. Credit: Jeff Mathison

Fig. 4.6.5.d. A leaking valve stem released calcium solution, which rusted the rim. A major expense will be incurred, and using this tractor presents a severe safety hazard. Credit: Jeff Mathison

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

Safety Activities

1. Research how to identify the size of a tractor tire and then complete a price comparison search for the tractor tire. For comparison purposes, complete an online search to identify various price options.
2. Have an adult mentor, leader, or teacher show you how to check air pressure for a tire with liquid ballasts.
3. Find out how much a rear tractor tire weighs equipped with a liquid ballast. Complete an online search for tractor tire repair service or tire dealers.
4. Contact a local tractor tire dealer to review what the recommendations are for filling tractor tires with liquid ballast.
5. Research the purpose of tractor ballast.

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses and Golf Courses. John Deere Publishing, 2001.

HOSTA Task Sheet 4.6.6

The Operator Platform

Learning Goals

- Understand the need to keep steps and platform clear of tools and debris at all times
- Adjust the tractor seat and seat belt to safely reach all controls while your seat belt is buckled

Related Task Sheet

- 4.6: Preventive Maintenance and Pre-Operation Checks

Introduction

The tractor operator platforms are designed to allow the operator to safely start and operate the tractor and may include the following features:

- Steps
- Adjustable operator seat with seat belt
- Multiple controls at hand and foot positions
- Windshield, doors, and windows if equipped with cab enclosure

Keep this zone free of obstructions for safe operation. The platform can become hazardous if:

- Steps are covered with mud and/or manure
- Floorboard is cluttered with chains, grease guns, tools, and hitch pins
- Visibility is reduced due to dirty windows or mirrors
- Controls are out of reach because of a poorly adjusted seat

This task sheet discusses the need for a clean clutter-free tractor operator platform and an adjustable seat to safely reach the operating controls.

Figure 4.6.6.a. This cluttered operator platform increases the risk for injury. Operators must have room to operate hand and foot controls. Items can roll or be wedged under control pedals, which prevents correct, timely operation of the controls. Credit: Penn State Extension Ag Safety Team

Operator Platform Workplace

The tractor platform is designed for the safety of the operator.

Figure 4.6.6.b. Falls account for many farm injuries. Keep the steps and platform clean of mud, manure, and tools. Credit: Penn State Extension Ag Safety Team

Figure 4.6.6.c. Tractors with ROPS come equipped with seat belts. Use them. Credit: Penn State Extension Ag Safety Team

Figure 4.6.6.d. Keep windows and mirrors clean for good visibility. Credit: Penn State Extension Ag Safety Team

Seat Adjustment

Each person who operates the tractor will be a different height and weight. Check and adjust the seat so that you can comfortably reach all controls. Be sure the seat belt is also adjusted for the seat. This should be one of the first tasks before starting the tractor.

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

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

Figure 4.6.6.e. Locate seat adjustments and know how they work. You may need the operator's manual. Credit: Michael Houtz, Penn State

Figure 4.6.6.f. 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. Your legs should remain slightly angled while the foot pedals are fully depressed. Credit: Jeff Mathison

When used with a rollover protection system, seat belts keep tractor drivers from being thrown out of zone of protection in the event of a rollover.

Safety Activities

1. Inspect an operator station of a tractor on a farm. Provide an assessment of the condition of the operator platform. List how many different objects you can find there.
2. Use the NIOSH website at **www.cdc.gov/niosh/injury/data.html** to locate data on injuries due to falls in agricultural work.
3. Conduct a farm survey in the area with the help of you or class members to determine how many tractors have seats or seat belts that can be easily adjusted.

References

National Institute for Occupational Safety and Health. "Traumatic Occupational Injuries: Data and Statistics." **www.cdc.gov/niosh/injury/data.html**.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Starting and Stopping Diesel and Gasoline Engines

Learning Goals

- Safely start and stop the engine of a gasoline tractor
- Safely start and stop the engine of a diesel tractor
- Explain the differences between gasoline and diesel engines

Related Task Sheets

- 4.4: Tractor Instrument Panel
- 4.5.1: Engine Stop Controls
- 4.8: Mounting and Starting the Tractor

Introduction

Starting a farm tractor requires more than just turning the ignition key. A safe operator will be able to think clearly and know the function of each control. Tractors vary in design and layout of the instrument panel and control system. However, starting and stopping a spark ignition or compression ignition engine involves only slight differences due to the type of fuel used to operate the engine. This task sheet discusses how to start and stop both compression ignition and spark ignition farm tractor engines.

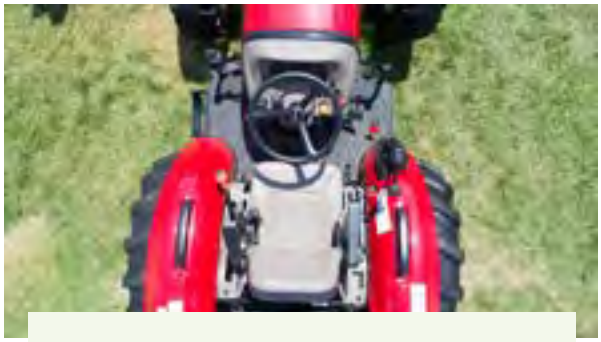


Figure 4.7.a. Tractor controls may not be easy to identify, especially on older model tractors. If you are not sure, refer to the owner's manual and get instruction from someone who knows the safe operation of the farm tractor. Credit: Michael Houtz, Penn State

Never operate an internal combustion engine inside a building or partially enclosed area. Buildup of toxic fumes produced can be fatal.

Before You Start the Engine

For both types of engines, conduct a pre-operation check:

1. Check starting oil, fuel, and coolant levels (cold engine only).
2. Check the tires.
3. Check the controls for neutral positions.

For all engines, avoid bypass starting. Many tractors have had their safe start systems bypassed. This is an unsafe practice. If the tractor is in gear, the tractor will move forward and crush you. Start the tractor from the seat only. The bypass starting hazard is discussed in Task Sheet 4.8.

Spark ignition systems most often combust gasoline as the fuel. However, there are other fuels used with this ignition system, such as LPG or propane. The fuel is metered and delivered using a carburetor. The typical process for starting a spark ignition system is as follows:

- A starting mechanism is used to rotate the crankshaft of the engine, which moves the piston in the cylinder.
- Air/fuel mixture enters during the intake stroke as the piston moves in the cylinder.
- The piston will then travel to the top of the cylinder to compress the air/fuel mixture. At the power stroke, a spark plug ignites the mixture, resulting in the engine starting.

Compression ignition systems typically combust diesel as the fuel. Fuel is delivered using injector nozzles, which are pressurized by an injection pump. The process of starting a compression ignition system will typically include the following:

- A glow-plug may be used to preheat the cylinder to aid in starting. Once the glow-plug has been heated, a starting mechanism is used to rotate the crankshaft of the engine, which moves the piston in the cylinder.
- During the intake stroke, the piston travels down the cylinder, drawing in clean fresh air.
- As the piston travels toward the top of the compression stroke, the air is heated by the compressive forces of the piston traveling in the cylinder.
- At the top of the compression stroke, the injection pump forces fuel to the injectors, which spray fuel droplets into the hot air, igniting the fuel and resulting in the engine starting.

A cold engine must be choked to start easily. Choking increase the amount of fuel in the air/fuel ratio.

Figure 4.7.b. Choke the engine on cold days to allow more fuel than air to enter the combustion chamber. Release the choke after the engine has started—the fuel-rich mixture will foul the spark plugs and valves of the engine. Illustration by Andy Mylin

Figure 4.7.c. Set the throttle to 1/3 of the working range. Illustration by Andy Mylin

Starting and Stopping Gasoline Engines

Follow these steps after you have fastened your seat belt.

1. Check that the transmission is in neutral. Engage the clutch and brakes.
2. Turn starter key to "on."
3. Check indicator lights/gauges for oil pressure, temperature, and electrical charge.
4. Choke the engine to aid in cold start.
5. Adjust throttle to 1/3 open.
6. Turn key to "start" position to energize the starter. Do not run the starter for more than 10 to 30 seconds to avoid damaging the starter or running down the battery.
7. Recheck gauges, especially the oil gauge.
8. Once the engine is started allow it to reach operating temperature by idling at 800 to 1,000 RPMs for a few minutes.

To stop the gasoline engine:

1. Bring the tractor to a complete stop. This can be accomplished by engaging the clutch and brake.
2. Place tractor in park or neutral and set parking brake.
3. Set the throttle back to idle speed. Allow the engine to idle for several minutes, especially after heavy loading, to allow the oil to cool. If you do not allow the engine oil to cool, it can cause premature engine failure.
4. Turn the ignition switch to the "off" position. This will ground the ignition circuit that provides electricity to the spark plug.
5. Remove the key to prevent accidental starting by an untrained person.

Figure 4.7.d. Be sure fuel pump shut-off knob is in the "on" position. If the conditions are cold, turn the ignition key to the glow-plug setting and hold until the indicator shows that the combustion chamber is hot enough to ignite the diesel fuel droplets. If you don't know how to do this, ask someone to show you. Credit: Penn State Extension Ag Safety Team

Figure 4.7.e. Set the throttle to 1/3 of its working range. Credit: Penn State Extension Ag Safety Team

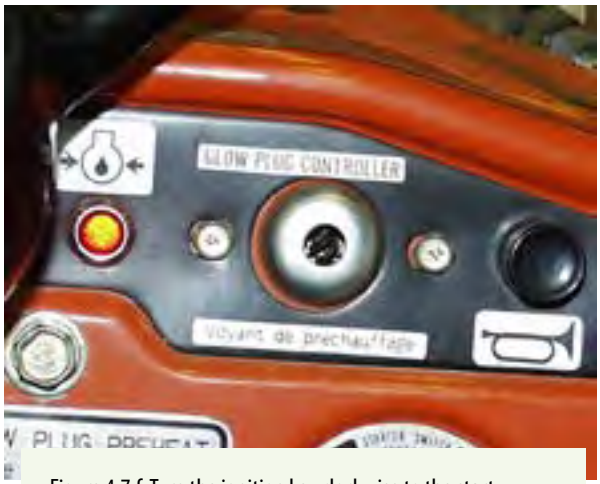


Figure 4.7.f. Turn the ignition key clockwise to the start position. Do not hold it there for extended periods of time. This can damage the starter motor or drain the battery of its charge. Credit: Penn State Extension Ag Safety Team

Starting and Stopping Diesel Engines

Follow these steps after you have fastened your seat belt.

1. Check that the transmission is in neutral. Engage the clutch and brakes.
2. Adjust throttle to 1/3 of the working range.
3. On cold days, turn ignition key to the "on" position, which will warm the glow-plug, if equipped (glow-plugs preheat 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 key to "start" position to energize the starter. Do not run the starter for more than 10 to 30 seconds to avoid damaging the starter or running down the battery.
6. Recheck gauges, especially oil gauge.
7. Allow the engine to idle at 800 to 1,000 RPMs until the engine reaches operating temperature.

To stop the diesel engine:

1. Bring the tractor to a complete stop. This can be accomplished by engaging the clutch and brake.
2. Place tractor in park or neutral and set the parking brake.
3. Set the throttle back to idle speed. Allow the engine to idle for several minutes, especially after heavy loading, to allow the oil to cool. If you do not allow the engine oil to cool, it can cause premature engine failure.
4. Turn the ignition switch to the off position. On newer tractors this will shut off the delivery of fuel to the engine. For older tractors and some modern style tractors, you will need to manually pull a "red" fuel pump shut-off control rod. This pull knob will be marked "STOP." Be sure to remove the ignition key to prevent an untrained person from starting the tractor.

Stopping a diesel engine requires shutting off the fuel pump.

Safety Activities

1. Using the procedures listed earlier, practice starting and stopping gasoline and diesel tractor engines.
2. Trace the linkage of the choke lever on the gasoline engine from the carburetor to the instrument panel. Draw a sketch of that linkage path.
3. Trace the linkage of the diesel fuel flow from the fuel tank to the fuel pump to the injectors. Draw a sketch of the linkage that leads from the fuel pump to the "red" fuel shut-off switch located on the operator's platform or instrument panel.
4. True or false? Gasoline engines do not give off dangerous fumes.
5. Choking an engine to start it on a cold morning means:
   a. Holding the key in the start position for as long as it takes.
   b. Providing more fuel than air for better ignition.
   c. Gasing the engine by pumping the throttle.
   d. Pouring extra fuel into the air cleaner to start the engine.
6. Diesel engines do not have spark plugs. How is diesel fuel ignited in the cylinder?
7. Why should a cold engine be allowed to warm up before pulling a heavy load?
8. What can happen to the tractor's parts if you crank the starter motor too long?
9. True or false? Diesel engines do not give off carbon monoxide.
10. True or false? Diesel engines give off carbon dioxide gases.
11. What are the lethal gases given off by a gasoline engine called?
    a. Carbon dioxide
    b. Carbon trioxide
    c. Carbon monoxide

12. Where are glow-plugs found? What do they do?

References

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses and Golf Courses. John Deere Publishing, 2001.

Mounting and Starting the Tractor

Learning Goals

- ◊ Mount a tractor safely
- ◊ Understand the hazards of bypass starting
- ◊ Know safe tractor startup procedures

Related Task Sheets

- ◊ 4.7: Starting and Stopping Diesel and Gasoline Engines
- ◊ 4.9: Stopping and Dismounting the Tractor

Introduction

Safe tractor operation includes climbing onto the tractor in a safe way. Many operators have bruised shins and broken bones from slipping and falling while recklessly climbing or jumping onto tractors. Specific tractor pre-operation checks have been discussed, but there are other items to consider to safely start the tractor.

This task sheet identifies the safe way to mount a tractor and the starting procedures to use.

Always take your time and mount the tractor safely.

Safe Tractor Mounting

Establish yourself as a good tractor operator by using these procedures each time you climb onto and sit down on a tractor seat.

- ◊ Keep the operator platform free of tools, equipment, and mud or other debris.
- ◊ Use handholds and steps as you mount the tractor. 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 ROPS).
- ◊ Check the major controls (PTO, hydraulics, gearshift stick) for the neutral (or PARK) position.

Figure 4.8.a. Mount a tractor safely by using the handholds and steps. Scraped shins, along with worse injuries, have occurred when handholds and footsteps are not used. Credit: Jeff Mathison

Before You Start the Engine

The safe operator will then think about and check many things before turning the key.

1. Is the area immediately around the tractor clear of people and animals?
2. Is the tractor inside a building? If yes, is the building as open as possible to avoid a buildup of carbon monoxide fumes?
3. Do you understand the tractor's instrument panel?
4. Have pre-operation checks been made?

Now you are ready to start the tractor.

Bypass Starting Dangers

Safe start systems have been in tractors for many years. The most common example of the safe start system is when the gearshift must be in neutral and the clutch must be depressed for the tractor to start. Some newer tractors may also have a switch in the seat that prevents the tractor from starting if the operator is not sitting in the seat. Safe 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, the same operator who makes this mistake in judgment is also the operator who misjudges the location of the gearshift and has the tractor in gear while attempting to bypass start the tractor. The result is a tractor that lurches forward with the rear wheel running over and crushing the operator. Every year, experienced and inexperienced tractor operators die from bypass starting. Do not be one of them!

Figure 4.8.b. Newer tractors have covers on the starters to prevent bypass starting. Do not attempt to bypass start any tractor. Credit: National Children's Center for Rural and Agricultural Health and Safety

Start the tractor engine from the seat only.

Safety Activities

1. Practice your safe mounting technique in front of a parent, instructor, or classmate. Explain each step as you complete it.
2. Visit area farms and equipment dealers, and record how many tractors have some type of safe start system. See how many different systems you can find.
3. What are the dangers of bypass starting?

Reference

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Stopping and Dismounting the Tractor

Learning Goals

- Understand safe tractor shutdown procedures
- Learn to dismount a tractor safely

Related Task Sheets

- 4.7: Starting and Stopping Diesel and Gasoline Engines
- 4.8: Mounting and Starting the Tractor

Introduction

Stopping and shutting off a tractor at the end of a day or for an extended period of time involves some specific procedures. Safe tractor operation includes climbing down from the tractor in a safe way. Many operators have ended up with twisted or broken bones from slipping and falling while recklessly jumping off tractors.

This task sheet identifies safe tractor shutdown procedures and the safe way to dismount from a tractor.

Stopping the tractor is more than turning the ignition key to the "off" position.

Shutting Down the Tractor

At the end of a day, there are many things to think about as you prepare to park and shut the tractor off for a period of time or for the night.

- Cool the engine. 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.
- Relieve pressure in the hydraulic system. Even if you did not use the hydraulic system recently, static pressure keeps hydraulic lines pressurized. Work the hydraulic controls to relieve that 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) or 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 to prevent runaways if a heavy load is attached to the tractor.

Figure 4.9.a. To prevent falls, use the handholds and footsteps provided to dismount from the tractor. Falls while dismounting account for many farm injuries each year. Credit: Penn State Extension Ag Safety Team

Safe Tractor Dismounting

The keys to safely dismounting are:

- ◊ Keep the operator platform free of tools, equipment, and mud or other debris.
- ◊ Face the tractor, and use handholds and steps that are provided. Try to keep three points (two hands and one foot or two feet and one hand) on the tractor at all times.
- ◊ Take the key with you. Untrained operators, children, and visitors cannot accidentally start the engine if the keys are removed.

Figure 4.9.b. The key has been removed from the ignition. Untrained operators and children cannot start the tractor if the key is removed from the ignition. Michael Houtz, Penn State

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

Safety Activities

1. Practice your safe tractor shutdown procedure in front of a parent, instructor, or classmate. Explain each step as you complete the procedure.
2. Ask the tractor owner(s) what policy they have for removing the keys from tractor ignition switches when the tractor is not in use.
3. If chock blocks are not available for wagons and implements at home, manufacture chock blocks in your school shop or home shop area.

Reference

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Moving and Steering the Tractor

Learning Goals

- Move a tractor without stalling or jerking through proper use of the clutch control pedal or lever
- Steer a tractor without damaging the tractor or towed or attached machine

Related Task Sheets

- 4.5.2: Ground Motion Controls
- 4.10.1: Operating a Manual Shift Transmission
- 4.10.2: Tractor Transmissions
- 4.14: Operating the Tractor on Public Roads
- 5.1: Connecting Implements to the Tractor

Introduction

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 stunts. "Popping the clutch" or doing "wheelies" will result in damage, injury, or death. You must be able to move the tractor in a safe and efficient manner.
- Tractors and implements are wider and longer than automobiles. You must judge the area needed to turn or to drive between objects.

This task sheet discusses moving and steering the tractor by smoothly engaging the drive train and paying attention to the space occupied by the equipment.

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

Before the Tractor Moves

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

1. Allow for a smooth start
2. Interrupt power while changing gears
3. Interrupt power when stopping

Foot control pedal or hand control levers/ joysticks are used to control tractor movement. Remember that these controls are orange color-coded controls. Older tractors may not have color-coded controls. Ask for help with identifying the controls.

Figure 4.10.a. Start the tractor moving smoothly. Excessive engine speed can the cause the tractor to start with a jerk. Illustration by Andy Mylin

An expert tractor operator moves the tractor without stalling or jerking.

Transmission and Clutch Types You May Use

Transmissions can be divided into four general categories:

1. Manual shift transmissions, where the operator uses one or more shift levers to change gears and power range.
2. Hydrostatic transmissions, where the operator pushes a control lever or pedal to engage a hydraulic pump to a hydraulic motor that turns the drive wheels.
3. A combination of gear-driven and hydraulically assisted transmissions, where 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.
4. A continuously variable transmission (CVT), which operates using a pair of variable-diameter, cone-shaped pulleys connected by a steel or composite belt. One side of the pulley is actuated by a hydraulic cylinder, which increases or decreases the amount of space between the pulley to change the "gear" ratio.

Figure 4.10.b. Remember that orange-colored control levers indicate ground motion controls. If the shift pattern is hard to locate, ask someone who is familiar with the tractor to show you the shift pattern. Credit: Michael Houtz, Penn State

Skills for Moving the Tractor

Before attempting this skill, examine the operator's manual and have a qualified operator demonstrate what you must do.

To start moving the tractor:

1. Check the controls as you have learned in Task Sheet 4.5.2, adjust the seat, and fasten the seat belt.
2. Start the engine with the brake and clutch fully depressed. You may need to be in park or a neutral start position on many tractors.
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 you feel the tractor begin to move.
5. Release the clutch and brakes fully when you are moving. Partial engagement (riding the clutch) can heat and place wear on 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 affect the operation of towed equipment.

Steering Involves Many Concepts

Steering involves several concepts, each dealing with spacing. You must have knowledge of the:

- ◊ Width and length of the tractor
- ◊ Width and length of the tractor and attached implement
- ◊ Space needed to corner the tractor and equipment around a building or object
- ◊ Differences in the turning radius of narrow front-end versus wide front-end tractor steering
- ◊ Individual wheel brakes on the tractor that can also be used to steer or control slippage on steeper slopes

Brakes can help make steering corrections in tight places. Since 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, as brakes can wear out quickly.

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

Figure 4.10.c. Use both hands to steer the tractor. If you hit a hole in the field, the wheel can be jerked from your hand. Credit: Penn State Extension Ag Safety Team

Cornering

Before attempting this skill, have a qualified operator demonstrate what you must do before you attempt cornering. Each tractor and implement will also occupy a different space and corner differently. Know the relationship between the tractor and any towed implement. Too tight of a 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. Too tight of a turn can cause damage to the tractor, the tires, or the towed equipment.
- ◊ As you complete the turn, observe the outside or opposite side of the tractor to be sure it has clearance from any other objects.

Wide turns on public roads will place the tractor and equipment into the opposite lane of traffic. This creates a hazard.

Figure 4.10.d. Too tight of a turning radius can damage tractor, tires, or implement. Illustration by Jeff Mathison

Safety Activities

For moving and steering the tractor:

1. On the tractor to which you are assigned, learn where the ground motion controls are found. This includes:
   - ◊ Clutch control pedal or lever
   - ◊ Gear shift pattern
   - ◊ Shuttle shift and/or shift lever
2. In a large, open area, practice starting a tractor, moving it forward, and slowly steering it in a figure 8 pattern. Then place the tractor in reverse gear and slowly back through the figure 8 pattern. Use a low-range gear and a low-speed throttle adjustment.
3. Ask an experienced operator to show you how to move a tractor and implement uphill and downhill from a standing start.

For steering the tractor:

1. Use a 4-H or FFA Tractor Driving Course layout to practice driving a tractor through a course. You can also use the Driving Course Exam Layout from this program or develop your own challenging course.
2. Complete the obstacle course by using the reverse gear and backing through the course using the tractor alone.
3. Make the obstacle course a little larger (use the course layout guide to determine the size of the driving course as described in NSTMOP); repeat the practice with a tractor towing a two-wheeled implement. As you develop skill, reduce the size of the opening and practice further. You may make the course smaller as you achieve greater skill.

Reference

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Operating a Manual Shift Transmission

Learning Goal

◊ Be able to select and use the various gears of the standard shift transmission effectively without damage to the tractor.

Related Task Sheet

◊ 4.10: Moving and Steering the Tractor

Introduction

Often referred to as a "stick shift," a manual transmission requires the operator to manually set the transmission into a specific gear and range to change the tractor's drive-wheel speed and torque in relation to engine speed and torque. There is a skill involved in doing this task. If done properly, a smooth change is noticed; if done improperly, gears will clash and transmission wear will increase.

This task sheet focuses on the safe operation of a tractor equipped with a manual transmission to minimize transmission gear wear or damage.

Gear Shift Pattern

The shift lever used to change gears will often be labeled with either a lettered decal or numbers embossed into the steel case or in the shift lever knob. This positioning label should be read from the operator's seated position. The middle or N position is neutral. Sometimes the gear pattern labels are worn to the point that you cannot see them, causing the operator to have to ask for assistance or locate the gear pattern themselves.

If you cannot see a pattern, ask your supervisor to show you. Refer to the operator's manual for information on the gear shift pattern. You may also contact an equipment dealer to locate information on the gear shift pattern.

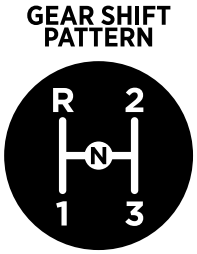


Figure 4.10.1.a. (A) The typical "H" pattern gear shift choice. Illustration by Andy Mylin

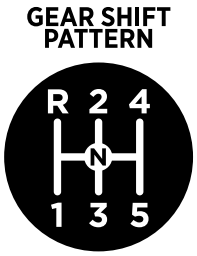


Figure 4.10.1.b. There may be five or six gear choices as well. Illustration by Andy Mylin

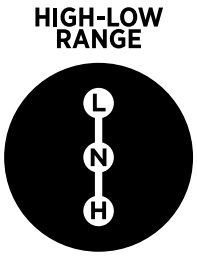


Figure 4.10.1.c. A high-low range shift lever found near the "stick" shift provides a faster or slower speed for a particular gear. Illustration by Andy Mylin

How It Works

Depressing the clutch will disengage the friction disk (clutch plate) that transfers the engine power to the transmission. When the clutch is depressed, the engine will continue to run and the transmission 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 a variety of gear choices depending on the transmission and if the tractor is equipped with a high- and low-range option.

If you don't know or can't find the gear shift pattern, ask your supervisor to show you.

Proper Selection of Gears

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

When pulling a light load, use a higher gear and reduce the throttle to maintain the desired ground speed. Tractors are more fuel efficient when used in a higher gear with a reduced throttle setting. This is difficult to do when using the PTO (power take-off) since 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. Refer to the operator's manual for proper gear selection for the task and check with your supervisor for help with understanding which gear to select.

Moving the Tractor

With the clutch and brake pedals pushed down to disengage the transmission and engage the brakes, increase the engine speed slightly to keep the engine from stalling when the transmission is engaged. Next, slowly let out on the clutch pedal until you feel movement, then simultaneously slowly let off the brake pedal. When the tractor begins to move, take your 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 as needed to limit the tractor from rolling on slopes.

Grinding or clashing gears means you are not timing engine speed with gear-shifting movements.

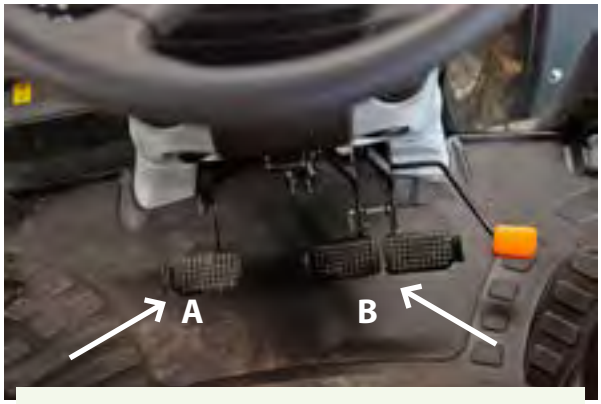


Figure 4.10.1.b. Depress the clutch pedal (A) and the brake pedals (B) at the same time. Start the engine. Select the proper gear to move the tractor. Then let out the clutch pedal smoothly. As you feel movement, also let off the brake pedal smoothly. Credit: Michael Houtz, Penn State

Gear up and throttle down for light loads.

Safety Activities

1. Locate the gear shift pattern decal or marking on a tractor. Draw and label the pattern if it is visible.
2. Sit in the operator's seat, push in on the clutch pedal, and practice shifting the gears in the pattern shown.
3. If the gear shift pattern markings are gone, ask the supervisor to show you the shift pattern.

Tractor Transmissions

Learning Goal

◊ Emphasize the need for ongoing training in the many types of transmissions found on farm tractors

Related Task Sheets

◊ 4.10: Moving and Steering a Tractor
◊ 4.10.1: Operating a Manual Shift Transmission

Introduction

Tractor transmissions will vary in their operation. It is important to know how to use them properly and safely to prevent damage to the machine. There are many transmission types available. Operators should be trained on how to use the specific transmission that they are expected to operate.

This task sheet briefly discusses tractor transmissions.

Know the gear shift pattern and how to smoothly shift gears without clashing or grinding.

Advice for Beginners

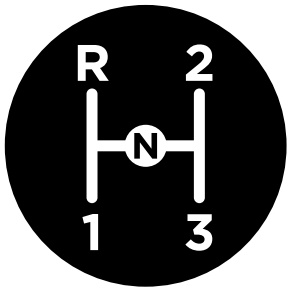
With the many variations in transmission shift patterns, several resources can be used to become familiar with the operation:

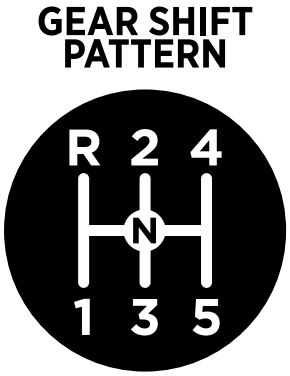
◊ Ask the tractor dealer or your employer to show you how the tractor is effectively shifted for various tasks.
◊ Read the operator's manual for the specific tractor to learn more about the transmission use.
◊ Search the Internet to help you find information about the specific type of transmission you will be using.
◊ To prevent injury to yourself and others, as well as damage to the tractor and other property, ask for training before using the tractor.

Manual Transmissions

There are many styles of manual shift transmissions used with tractors. This transmission is simple and durable. Entry-level employees may be assigned to these tractors until they gain experience before being assigned to more complicated transmissions.

Review the figure below for a reminder of what a stick shift gear pattern may look like and where the gear shift lever is located. The gear shift lever and high- and low-range shift are normally found on the transmission housing and between the operator's legs. See Task Sheet 4.10.1 for more information.





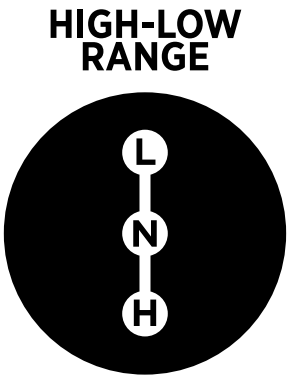


Figure 4.10.2.a. A tractor with a high-low range transmission has two shift levers (A). The transmission may have three to five gears with a high and low range for each. To start the tractor, both shift levers may have to be in neutral. The shift pattern decal may be worn or missing, requiring the operator to ask the employer for this information. Illustrations by Andy Mylin; photo by Penn State Extension Ag Safety Team

Other Transmission Types

While simple and durable, changing gears with a manual shift is inefficient. Tractor manufacturers developed a means of "shifting on the go" to improve tractor efficiency and increase operator comfort. The clutch pedal may still be used to disengage the transmission from the engine.

However, some newer model tractors will not use a pedal for shifting gears. The simple movement of the power (gear) shift lever gives a greater range of power and speed.

Many variations shown in the following figures. You must become familiar with the transmission you will be using. Study the operator's manual and ask for assistance from a knowledgeable person.

Figure 4.10.2.b. 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: Penn State Extension Ag Safety Team

Figure 4.10.2.c. Visual monitoring of speed and power ranges are made to assist the operator in efficient operation. Someone must explain the system to you so that you can operate the tractor properly. Credit: Michael Houtz, Penn State

Figure 4.10.2.d. Sophisticated controls and monitoring systems are found in the contemporary tractor's operator's station. Read the operator's manual and ask a reliable person to explain the tractor's operation. Credit: Michael Houtz, Penn State

Figure 4.10.2.e. Tractor's imported into the United States may not use the same color-coding standards for controls as tractors manufactured for the U.S. market. Request training before using imported tractors. Credit: Penn State Extension Ag Safety Team

Always look for the orange-colored controls. Keep in mind that some may be faded.

Continued Transmission Evolution Expected

Recent engineering developments in tractor transmissions combine hydraulic power with a synchronized gear train, adding an electronic monitoring system to further improve fuel savings and efficient use of the tractor. These newer transmissions initially cost more to purchase and require proper care to prevent damage. Here are a few of the possibilities:

- Electronic monitoring of 100 checks per second to modify tractor engine speed in relation to power requirements of the job.
- A declutch button to enable gear shifting on the go without depressing the clutch pedal. It conveniently allows the operator to increase transport performance and comfort, helping to save additional time.
- Electrohydraulic high-low range selection with the push of a button.
- Standard creeper range for work where slower speeds are required.

Ask for a demonstration of how the transmission of the tractor works.

Safety Activities

1. Locate the speed and power shift control lever on the tractor you will operate. Was it easy to find? What color is that control lever? Was the color worn to the point that you could not tell what color it was?
2. Sit in the operator's seat. Is there a clutch pedal? Can you move the speed and power control lever(s) while the engine is not running? Can you locate the shuttle shift, or reverser, lever? Where is the shuttle shift, or reverser, lever?
3. Try starting the tractor. Did it start when you followed the directions in the operator's manual? If it did not start, can you explain why?
4. On late model tractors, use the operator's manual to locate information about what speed and power setting to use for various field operations. Fill in the table below:

Field Work to Be Done	Transmission Setting	Engine RPM
A. Light load		
B. Heavy load		

Operating the Tractor in Reverse

Learning Goals

- Drive a tractor safely in reverse gear to a specific location with few directional corrections
- Spot the tractor drawbar to the hitch of the machine with no more than three changes of direction

Related Task Sheets

- 4.8: Mounting and Starting the Tractor
- 4.9: Stopping and Dismounting the Tractor
- 4.10: Moving and Steering the Tractor

Introduction

Not all operations will be in a forward direction. Being able to drive the tractor in reverse is important. Tasks such as hitching to equipment, backing equipment, unloading crops, and even storing machinery are done in reverse.

The safe and effective tractor operator must be alert and focused since this is one of the most difficult and hazardous tasks, especially if other workers are near the tractor.

Reverse travel and steering are generally done without looking at the direction of the steered wheels. These wheels will usually be out of your line of sight. You must master the concept that the steered wheels are pointing the rear of the tractor in the direction you want it to go.

To back safely, check your line of travel, back slowly, and have someone help direct you if needed.

This task sheet instructs how to correctly steer a tractor in reverse. Master this task without any equipment hooked to the tractor before beginning to back a two-wheel or four-wheel machine or implement.

Imagine which way the rear end of the tractor will go as you turn the steering wheel when moving in reverse.

Figure 4.11.a. It takes practice to drive a tractor safely in reverse. Credit: National Children's Center for Rural and Agricultural Safety and Health

Reverse Direction Hazards

People, animals, or other objects may be in the line of travel. As you look from the front of the machine to the rear, you may lose sight of such obstacles. Skid loaders and industrial equipment have reverse gear alarms to warn others, but tractors usually do not.

Workers who help you by hitching the implement to the tractor can be crushed if your foot slips from the clutch pedal, you are driving too fast in reverse, or you fail to steer in the correct direction in reverse. Do not permit the helper to go between the tractor and implement to be hitched before you stop the tractor and turn off the engine.

There is a tendency to shift slightly from the operator's seat when looking to the rear. You must stay in good contact with foot and hand controls to be safe.

Tips for Backing a Tractor

Follow these safety tips when driving a tractor in reverse:

1. Be sure seat and controls are adjusted for you.
2. Be sure all people, animals, and objects are clear of the tractor.
3. Place your hands at the bottom of the steering wheel (right hand at approximately five o'clock and left hand at approximately seven o'clock position).
4. Engage the clutch slowly, use a low engine speed, and maintain foot contact with the clutch and brake.
5. If you wish to move a two-wheeled implement to the left, you must turn the steering implement wheel with your left hand in a clockwise rotation. If you wish to move the rear of the two-wheeled to the right, move the steering wheel with your right hand in a counter-clockwise rotation. This must be done slowly.

Remember, when backing an implement, place your hands at the bottom of the steering wheel.

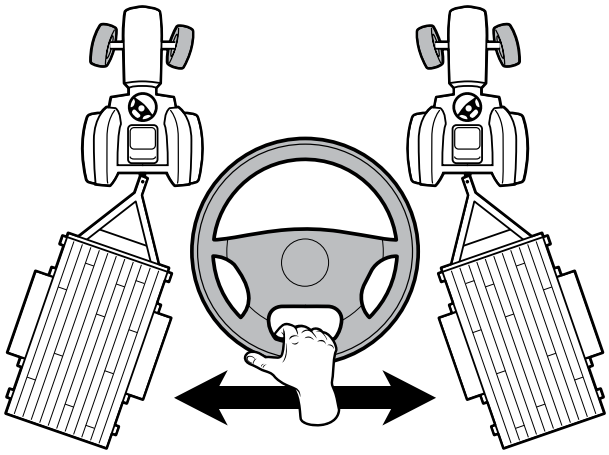


Figure 4.11.b Note the direction of movement the trailer or two-wheeled implement will turn. Remember to place your hands at the bottom of the steering wheel. Illustration by Andy Mylin

Safety Activities

1. With a clutch-type tractor, practice pushing the clutch in all the way and then releasing it slowly to get the feel of the clutch pressure. Do this first without starting the tractor and then practice this task in a clear area with the engine running.
2. Practice starting a tractor, moving it forward, and slowly steering in a figure 8. Place tractor in reverse gear and slowly back in a figure 8 pattern. Use a low-range, low-throttle adjustment.
3. Ask an experienced operator to demonstrate how to back a two-wheeled implement.
4. Practice turning and backing with a two-wheeled implement attached to the tractor.

Reference

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Tractor Stability

Learning Goals

- Explain the role that center of gravity plays in tractor overturns
- List reasons the center of gravity moves within a stability baseline
- Understand how to be protected during a tractor overturn

Related Task Sheets

- 4.1: Agricultural Tractors
- 4.2: Tractor Hazards
- 4.10: Moving and Steering the Tractor
- 4.13: Using the Tractor Safely
- 4.14: Operating the Tractor on Public Roads

Introduction

No other machine is associated more with farming hazards than the tractor. Estimates indicate that tractor overturns are responsible for the majority of fatal injuries on farms. Tractors are used for many different tasks and can be versatile machines. However, 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 your life if a tractor overturns while you are driving.

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

Keep the center of gravity inside the stability baseline.

How Tractors Overturn

The center of gravity (CG) is the point where all parts of a physical object balance one another. When you balance a pencil on your finger, you have found the pencil's CG. This is the part of the pencil that is resting on your finger. On a two-wheel drive tractor, CG is about 10 inches above and 12 inches in front of the rear axle. Figure 4.12.a shows the normal position of a tractor's CG.

Figure 4.12.a. Expected position of a tractor's center of gravity. Credit: Jeff Mathison

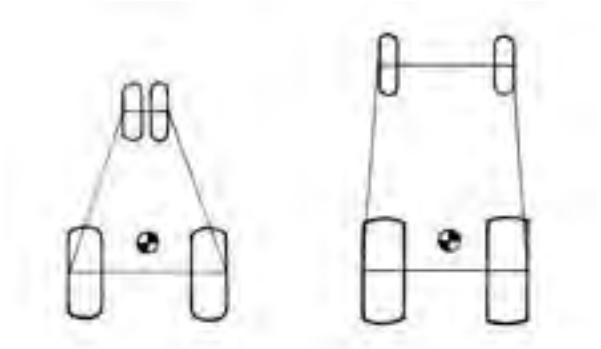


Figure 4.12.b. The tractor's center of gravity is inside the stability baseline. Illustration by Jeff Mathison

Figure 4.12.b shows that 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's 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.

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 you operate the tractor.

As you can see in Figure 4.12.b, a wide front-end tractor provides more space for the CG to move around without going outside the stability baseline.

Reasons the CG 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 higher 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 that is not hitched to the drawbar.

How Center of Gravity, Speed, and Slope Result in an Overturn

When a tractor is on a slope, the distance between the tractor's CG and stability baseline is reduced. Figure 4.12.c 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 be all that is needed for the tractor to overturn.

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

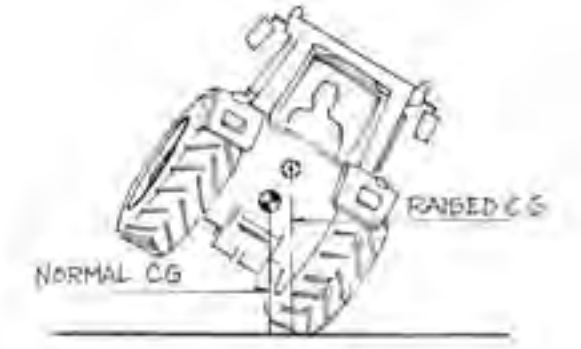


Figure 4.12.c. When a tractor is on a slope, the distance between the tractor's CG and stability baseline is reduced. Illustration by Jeff Mathison

When the bucket is raised high, the balance point for the whole tractor is also raised. Figure 4.12.d shows how a raised CG makes it easier for a tractor to turn over sideways.

Figure 4.12.d. A raised CG makes it easier for a tractor to turn over sideways. Illustration by Jeff Mathison

Centripetal force (CF) is the center-seeking force exerted on objects moving in a circular rotation. During a turn, CF is that force trying to keep the tractor from rolling over on its side whenever the tractor is turning. However, inertia of the tractor generated from the center of gravity is acting tangentially to the center of rotation. This pushes the tractor away from the center in a straight line.

These forces are additive. This means that if the inertia force is greater than the centripetal force, the tractor will continue in a straight line and experience a side overturn. The width of the wheel base, the center-of-gravity height, the turning radius, and the tractor's travel speed are the variables impacting a tractor side overturn.

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 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 speed may be needed to push the tractor over.

The tractor's transmission applies results in a rotating 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 torque will force the chassis of the tractor to rotate around the axle. 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. See Figure 4.12.e.

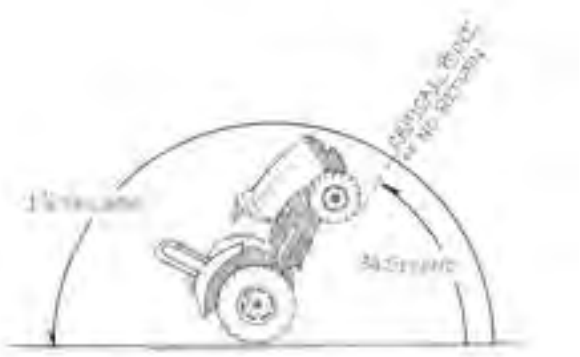


Figure 4.12.e. The point of no return is reached in ¾ of a second. Illustration by Jeff Mathison

The CG of a tractor is found closer to the rear axle than the front axle. A tractor may only have to rear back 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 4.12.e shows, this point can be reached more quickly than an operator can recognize the problem.

Common examples of this type of tractor overturn are the rear tires are frozen to the ground, tires are stuck in a mud hole, or tires are blocked from rotating by the operator. 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 4.12.f shows how this occurs.

Figure 4.12.f. When a tractor is pointed up a slope, the CG is closer to the rear stability baseline. Illustration by Jeff 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. The load is described as pulling down because the load is resting on the earth's surface. 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, including the drawbar, is 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 compromised. The heavier the load and the higher the "angle of pull," the more leverage the load has to tip the tractor rearward. Figures 4.12.g, 4.12.h, and 4.12i show important information about safe hitching points.

Figure 4.12.g. Only hitch to the drawbar. Credit: Jeff Mathison

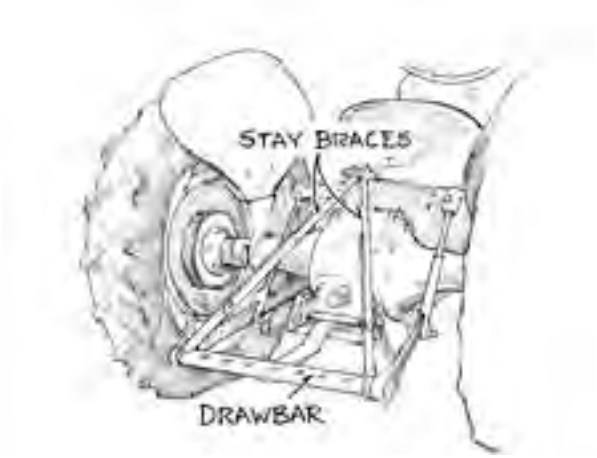


Figure 4.12.h. Never hitch to the top link of a three-point hitch. Credit: Jeff Mathison

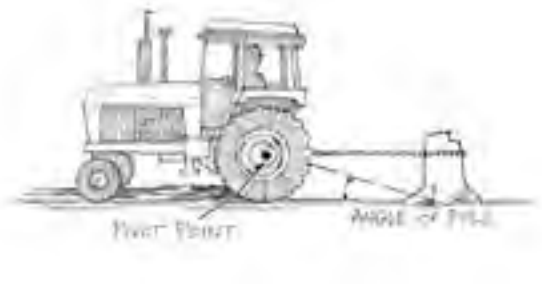


Figure 4.12.i. The angle of pull should be kept to a minimum. Illustration by Jeff Mathison

Protect Yourself in a Tractor Overturn

The rollover protective structure (ROPS) and seat belt, 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 it can prevent the operator from being crushed during an overturn. The operator must stay within the protective frame of the ROPS ("zone of protection") in order for the ROPS to work as designed. This means the operator must wear the seat belt. Not wearing the seat belt may defeat the primary purpose of the ROPS.

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, assuming that cab doors and windows are not removed.

To prevent tractors from overturning in the first place, follow the safety recommendations illustrated in Task Sheet 4.13.

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.

Safety Activities

1. Use a toy scale model or a full-size tractor to illustrate the five main reasons tractors overturn.
2. Invite a farmer who you know has survived a tractor rollover to speak to the class about the experience.

Figure 4.12.j. 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: Association of Equipment Managers

3. Conduct a survey of area farm people to find out 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 surviving the rollover?

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Farm and Ranch Safety Management. John Deere Publishing, 2009.

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Murphy, D. J., J. Myers, E. A. McKenzie, R. Cavaletto, J. May, and J. Sorensen. "Tractors and Rollover Protection in the United States." *Journal of Agromedicine* 15, no. 3 (July 2010): 249–63. doi: 10.1080/1059924X.2010.484309.

Using the Tractor Safely

Learning Goal

◊ Recognize proper uses of the tractor
◊ Recognize improper uses of the tractor

Related Task Sheet

◊ 4.1: Agricultural Tractors

Introduction

Tractors can be operated safely if they are operated as designed and recommended maintenance practices are followed.

There are hundreds of farm tractor fatalities each year. Examples of these preventable incidents include:

◊ 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 passenger grandson lives, when tractor goes over an embankment while going for a ride.
◊ Tractor overturns while towing stalled pickup full of firewood.
◊ Tractor upsets sideways while high-lift bucket is in a raised position while traveling across a rough slope.

This task sheet will identify several proper and improper uses of tractors.

A tractor is designed to do work.

Figure 4.13.a. When tractors are operated for their intended purpose, American farms produce more food than farms in any other country in the world. Credit: Michael Houtz, Penn State

Proper Use Defined

Tractors are made to work, not to be treated as recreational vehicles. Tractors serve four purposes:

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

If you are not sure of a specific use for your tractor, consult the owner's manual.

Proper Use Means Avoiding Improper Use

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

Figure 4.13.b. Tractors are designed for the operator only. No passengers allowed! Credit: Jeff Mathison

Figure 4.13.c. Tractors provide remote power to machinery. This turning shaft, the PTO, must be guarded to prevent entanglement hazards such as this. Illustration by Jeff Mathison

Figure 4.13.d. Hitch loads only to the drawbar. The drawbar has been engineered to pull heavy loads without risking a rear overturn hazard. Illustration by Jeff Mathison

Figure 4.13.e. If you are stuck or need to be towed, you will need help. Specific tools are needed for this job. This is a job for adults only. A strap or chain may break, creating a hazardous situation. Illustration by Jeff Mathison

Figure 4.13.f. 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. Illustration by Jeff Mathison

Figure 4.13.g. High speeds while making a turn can cause a sideways overturn. Make sure brakes are locked together. Reduce speed before entering the turn. Illustration by Jeff Mathison

Figure 4.13.h. 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. Illustration by Jeff Mathison

Figure 4.13.k. When operating a high-lift bucket with a load or without a load, keep the bucket as low to the ground as possible while in transport. Sideway overturns are possible if you try to travel with the bucket in the up position. Illustration by Jeff Mathison

Figure 4.13.i. Tractors are powerful, but each one has a limit to its pulling power. Overloading a tractor could stall the engine, but rearward overturns can occur as well. Illustration by Jeff Mathison

Figure 4.13.l. A tractor stuck in mud is immovable without help. Adult supervision is necessary. Illustration by Jeff Mathison

Figure 4.13.j. Field conditions pose special hazards to tractor operation. The operator must know where these obstructions and depressions are located. Illustration by Jeff Mathison

Figure 4.13.m. Avoid overhead power lines while transporting equipment to avoid risk of electrocution. Illustration by Jeff Mathison

Safety Activities

1. Start a collection of farm accident reports from magazines, newspapers, and farm newsletters.
2. Using a camera or video recorder, take photos or video film of unsafe tractor use situations. Make a display for your club, classroom, employee room, or farm shop.
3. Try this word search to find words related to proper tractor use. Words or phrases may be spelled forward, backward, up, down, or diagonally.
   Word list:

   ATTITUDE

   SAFETY

   GUARDS

   NO RIDERS

   OVERTURN

   ALERT

   LOW SPEED

   PTO

S	A	D	Z	C	D	E	F	G	H
J	A	T	T	I	T	U	D	E	I
K	N	F	D	L	M	G	N	O	P
Y	O	V	E	R	T	U	R	N	X
T	R	T	E	T	S	A	Y	R	Q
U	I	V	P	R	Y	R	O	W	X
D	D	C	S	E	B	D	A	Z	Y
L	E	F	W	L	G	S	H	I	J
K	R	L	O	A	M	N	O	P	Q
T	S	V	L	V	W	X	Y	Z	R

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"The Ten Commandments of Tractor Safety." Kubota Tractor Corporation, 2019. **https://www.kubotausa.com/service-support/safety/tractor-safety**.

Whitford F. et al. "Extracting Stuck Equipment Safely, Purdue Extension." **https://www.extension.purdue.edu/extmedia/ppp/ppp-98.pdf**.

Operating the Tractor on Public Roads

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

Learning Goals

- Understand the difference between farm equipment road use and normal highway vehicle road use
- Use all safe and courteous traffic driving practices to prevent farm equipment and motor vehicle crashes

Related Task Sheets

- 1.2: Safety and Health Regulations
- 2.3: Reaction Time
- 2.9: Hand Signals

Introduction

Tractor operators may travel many miles on public roads to reach different fields in order to plant, grow, and harvest crops. Slow-moving tractors and implements are no match for the general public's high-speed travels.

Traveling on public roads is hazardous because tractors are not designed with airbags or other safety features commonly found on automobiles.

Tractor operators must use extreme caution when traveling on a public road with farm equipment.

This task sheet discusses operating the tractor and equipment on public roads.

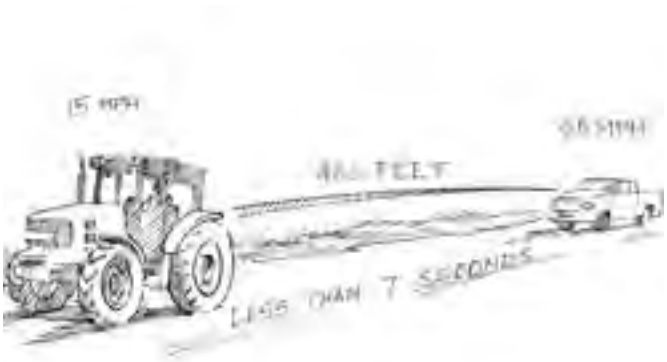

Figure 4.14.a. An automobile traveling 55 mph will cover the 400-foot distance between the automobile and tractor in less than 7 seconds. There will not be enough time for the driver of the automobile to react and stop before striking the back of the tractor. Illustration by Jeff Mathison

Movement Hazards

These situations create hazards when operating tractors on public roadways:

- Pulling slowly onto roads with long and heavy loads
- Slow tractor travel speeds
- Left turns across traffic into narrow field lanes
- Swinging into the left lane to make a right turn into a field
- Wide machinery being transported
- Potential for spilled loads

All rules of vehicle safety, as well as all rules of courteous driving, must be followed to prevent traffic-related collision incidents.

Obeying the Law

Each state varies in their highway regulations regarding the ages and 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 crossing over public roadways only or to operating equipment on roads that bisect or adjoin their farm.

Check with your local state police to learn more about the laws in your area. You must also obey all traffic laws and signs.

Lighting and Marking

American Society of Agricultural and Biological Engineers (ASABE) Standards for lighting and marking are summarized in the table below. Most farm equipment delivered from the factory today will be equipped to meet these standards. The equipment that you will use should comply with these standards. Older equipment can be improved with retrofit kits of lights and reflectors.

In the ASABE standard, rotary beacons and back-up alarms are add-ons depending on your needs. If accessories have been added, they should be in working order. Newer tractors are capable of speeds higher than 25 mph.

These tractors should be marked with an speed indication symbol (SIS).

Recommendations from ASABE for lighting and marking.

Item	Recommendation
Headlights	Two white lights mounted at the same level
Tail lamps	Two red lights mounted and facing toward 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-colored lights to the rear mounted with flashers
SMV emblem or SIS symbol	One visible at 1,000 feet mounted to the rear and 2–10 feet above the ground
Reflective markers	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

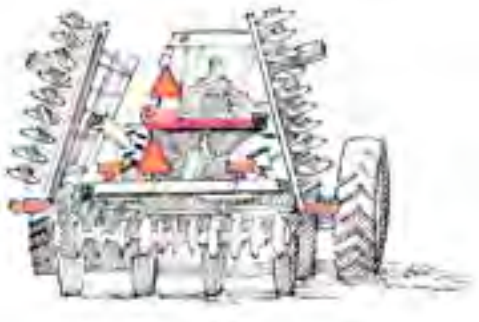

Figure 4.14.b. Lighting and marking standards may or may not be the standards for your state. Check your state laws. Illustration by Jeff Mathison

Figure 4.14.c. 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. Replace SMV emblems that are worn, damaged, or faded. Credit: Jeff Mathison

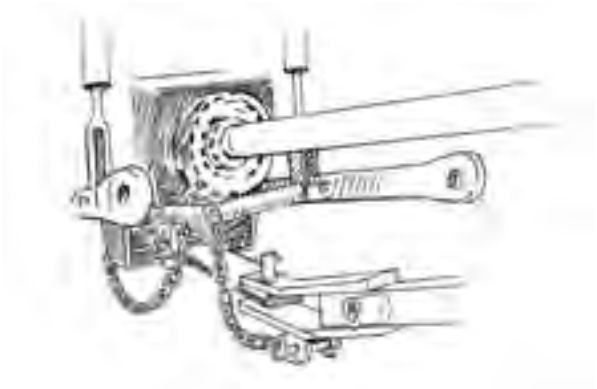

Figure 4.14.e. Use safety chains to ensure load hitching safety when possible. Trucks pulling farm loads should have safety chains also. Illustration by Jeff Mathison

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

Towing Safety

Figure 4.14.d. Secure hitch pins with locking clips as shown. Credit: Penn State Extension Ag Safety Team

Figure 4.14.f. 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. Newer tractors may need an SIS symbol as well. Credit: Jeff Mathison

General Practices for Tractors on Highways

Think about the following when traveling on the highway with farm machinery.

- ◊ Time of day. Avoid the busy times of the day to move equipment. Hauling large loads during early morning or late afternoon while people are hurrying to and from work creates traffic problems.
- ◊ Courtesy. Try to be as watchful of others as possible. Let the high-speed traffic go first. Your best manners on the highway will be the first safe practice to follow.
- ◊ Blind spots. There are locations that pose problems with visibility with large equipment. Use mirrors and backup cameras to increase your ability to see around the tractor while operating on the road.
- ◊ Shifting loads. If you upset a load of hay, spill a load of manure or a tank of pesticide mixture, or coat the road with mud from the field, you are responsible for getting help for cleanup and alerting traffic to be cautious. If manure or chemical spills endanger waterways, notify your employer, who may have reporting requirements with state environmental officials.
- ◊ Safe equipment. Your walk-around inspection should have shown you if you have 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.

Figure 4.14.g. 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: Jeff Mathison

Figure 4.14.h. Use accepted hand signals to inform other drivers of your intentions. Illustration by Jeff Mathison

When safe, pull completely off the road to let traffic flow past. Do not signal them to pass you. Signaling to motorists to pass makes you responsible for them.

Safety Activities

1. Measure the length of the longest tractor and implement combination with which you will work. Then have someone time how long it takes you to move the front end of that tractor to the rear end of the towed implement past a point or across the highway in front of the farm. How many seconds did it take to cross the road?

   _____ seconds
2. 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: 5,280 feet = 1 mile

   1 mile/minute = _____ feet/second
3. Multiply the answer (feet/second) in question number 2 by the time you recorded in question number 1. This is the distance the car going 60 mph will travel in the time it takes you to cross the road. Record the answer here: _____. Can you see that far as you pull out to cross the roadway?
4. Conduct a survey of the lighting, marking, and hitching of the tractors on your farm or farm of employment. Does it meet the safety requirements of your state?
5. Practice the hand signals for right, left, and stop that you will use while operating a tractor not equipped with turn signals.

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Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Lighting and Marking

Proper equipment marking and lighting is a must for roadway travel.

Learning Goal

◊ Understand the recommendations for lighting and marking of farm tractors and machinery

Related Task Sheets

◊ 1.2: Safety and Health Regulations
◊ 1.2.2: OSHA Act
◊ 1.2.5: State Vehicle Codes
◊ 2.9: Hand Signals
◊ 4.14: Operating the Tractor on Public Roads

Figure 4.14.1.a. 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: Jeff Mathison

Introduction

Today's farmers are traveling more miles on public roads than ever before to tend to livestock and plant, grow, and harvest crops. Slow-moving tractors and implements are no match for the public's high-speed travels.

Most crashes between farm equipment and motor vehicles occur during daylight hours and in good weather. You must be safe when traveling on public roads with farm equipment. Tractors and equipment must be clearly identified as slow-moving vehicles using recognizable lighting and marking.

This task sheet discusses lighting and marking as it relates to moving tractors and equipment on public roadways.

Lighting and Marking

The American Society of Agricultural and Biological Engineers (ASABE) Standard for Lighting and Marking is summarized in the table below. See **asabe.org** for more information.

Recommendations from ASABE for lighting and marking.

Item	Recommendation
Headlights	Two white lights mounted at the same level
Tail lamps	Two red lights mounted and facing toward 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-colored lights to the rear mounted with flashers
SMV emblem or SIS symbol	One visible at 1,000 feet mounted to the rear and 2–10 feet above the ground
Reflective markers	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

Most farm equipment manufactured today will use this standard. Exceptions to the standard may occur with equipment manufactured outside the United States. Many states use a similar standard in their Motor Vehicle Codes to specify lighting and marking of slow-moving vehicles and farm equipment.

Lighting and marking on older equipment can be improved to meet this standard with add-on lights and reflectors kits.

Is Your Lighting and Marking Adequate?

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

- Slow-moving speed shown by SMV emblem or SIS symbol
- Extremities of width defined by side marker lights or decals
- Ability to warn of turns by recognizable signals

If the tractor and equipment or self-propelled equipment do not meet these requirements, the operator increases the risk of injury to themselves and the public.

Figure 4.14.1.b. Lighting and marking features used on this tractor and grain drill: number 1 is the SMV, number 2 shows hazard and signal lights, and number 3 is the conspicuity material as a red retro-reflective marker. Credit: Jeff Mathison

Safety Activities

1. Clean all the lights, SMV emblems, and reflective markers daily on the farm equipment you will operate.
2. Conduct an inspection of all tractors and equipment on a local farm. Make a list of lighting and marking deficiencies you find.
3. Using the Internet, search your favorite brand of tractor or machinery to access pictures that show the lighting and marking methods used. Determine whether or not these machines meet the ASABE standards.

References

ANSI/ASABE, S279.12 Lighting and Marking of Agricultural Equipment on Highways. American Society of Agricultural and Biological Engineers, St. Joseph, MI.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

5

Section Five
Connecting and Using Implements with the Tractor

Connecting Implements to the Tractor

Learning Goals

- ◊ Safely connect an implement to the tractor's drawbar
- ◊ Safely connect an implement to the tractor's three-point hitch

Related Task Sheets:

- ◊ 4.12: Tractor Stability
- ◊ 4.13: Using the Tractor Safely
- ◊ 4.14: Operating the Tractor on Public Roads
- ◊ 5.2: Using Drawbar Implements
- ◊ 5.3: Using Three-point Hitch Implements

Introduction

Your supervisor on the farm has asked you to connect (hitch) the hay rake to the tractor and be in the nearby field within five minutes. Being able to steer the tractor in reverse while smoothly operating the clutch and brakes will be critical. The next step will be to hitch the load to ensure tractor stability.

This task sheet provides an overview of safe and efficient hitching of implements to the tractor. Additional details will be discussed in Task Sheets 5.2 and 5.3.

Hitch points should match the implement being attached to the tractor! Improper hitching can result in serious injury or death.

Hitching and the Center of Gravity

Remember that tractor stability is impacted by the tractor's center of gravity and stability baseline.

Tractor hitches are designed so the downward and rearward forces 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 to the drawbar only.

Pulling a load with the downward and rearward forces above the tractor's center of gravity will result in a rear overturn. You must hitch only to the drawbar to prevent the tractor from rearing up and turning over. Even small lawn and garden tractors can flip rearward if not properly hitched to a load.

A bolt lying 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.

Figure 5.1.a. An example of safe hitching. The drawbar will lower if the front end lifts off the ground. This reduces the "angle of pull" and the risk of a rear overturn. Illustration by Jeff Mathison

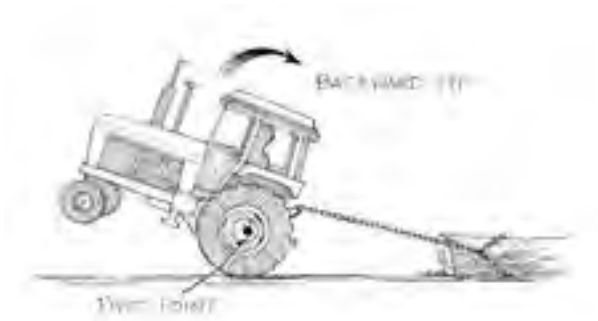

Figure 5.1.b. The log is fairly immovable. A chain hooked above the center of gravity of the tractor (e.g., top of three-point hitch bracket) allows a rearward tip of the tractor. Improper hitching has overridden safe tractor engineering design. Many people have lost their lives as a result. Illustration by Jeff Mathison

Figure 5.1.c. 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 midpoint between the rear tires to maximize pulling power. Hillside operations may require a drawbar adjustment to one side to balance the pulling forces. Credit: Jeff Mathison

Figure 5.1.d. Tractor drawbars are designed at the correct height from the ground to keep the pull forces below the center of gravity. Credit: Jeff Mathison

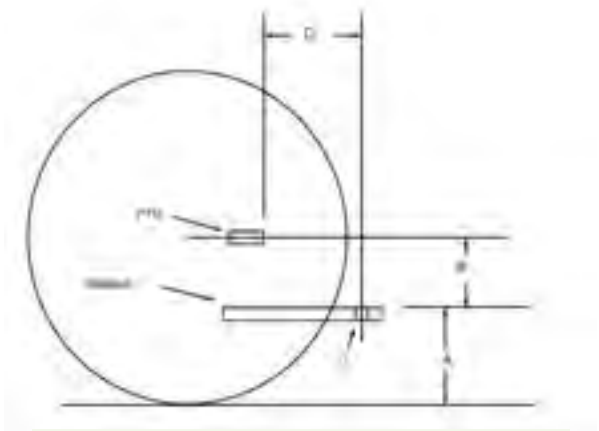

Figure 5.1.e. The tractor power take-off and drawbar position are designed with specific measurements for the size and horsepower rating of the tractor. The operator should not make changes to these design standards by changing the hitch point.

Table 5.1.a lists the measurements and relationships at points A, B, C, and D above for each range of tractor size. Only use the drawbar to tow a load. A swinging or floating drawbar permits adjustment of the center line of pull to be maintained even on a hillside.

Table 5.1.a. Drawbar sizing and positioning standards (ASAE S482).

Item	Drawbar Hitch Category I	Drawbar Hitch Category II	Drawbar Hitch Category III	Drawbar Hitch Category IV
Tractor PTO HP (kW)	≤ 64 (≤ 48 kW)	≤ 154 (≤ 115 kW)	≤ 248 (≤ 185 kW)	≤ 402 (≤ 300 kW)
Minimum Drawbar Height Above the Ground (A)	~13 to 20 inches (330 to 500 mm)	~13 to 20 inches (330 to 500 mm)	~15 to 22 inches (380 to 560 mm)	~15 to 22 inches (380 to 560 mm)
Drawbar to PTO (B)	~9 inches (220 mm)	~10 inches (250 mm)	~10.25 inches (260 mm)	~11 inches (280 mm)
Hitch-Pin Hole Size (+0.03 to 0.010 inch) (C)*	~1.3 inches (33 mm)	~1.3 inches (33 mm)	~1.6 inches (41 mm)	~2.06 inches (52.5 mm)
Nominal Hitch Pin Size (minimum to maximum)*	~1 to 1.25 inches (30 to 31.4 mm)	~1 to 1.25 inches (30 to 31.4 mm)	~1.5 inches (38 to 39.4 mm)	~2 inches (50 to 51.2 mm)
Drawbar Dimensions (max. thickness by max. width)	~1.4 inches by 2.6 inches (36 mm by 67 mm)	~2 inches by 3.5 inches (52 mm by 90 mm)	~ 2.25 inches by 3.5 inches (57 mm by 90 mm)	~2.5 inches by 5.1 inches (64 mm by 130 mm)
Regular Position Distance from 540-RPM six straight spline type PTO Stub Shaft to Drawbar Hitch Hole (±0.40 inch) (D)*	~14 inches (350 mm)	~14 inches (350 mm)	~14 inches (350 mm)	~14 inches (350 mm)
Regular Position Distance from 1,000-RPM 21 involute spline type PTO Stub Shaft to Drawbar Hitch Hole (±0.40 inch) (D)	~15.75 inches (400 mm)	~15.75 inches (400 mm)	~15.75 inches (400 mm)	~15.75 inches (400 mm)

*Shorter drawbar positions are not to be used during PTO operation.

The Three-Point Hitch

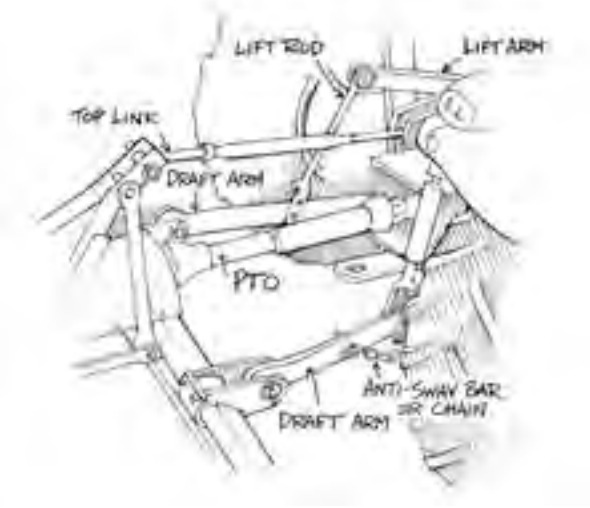

Figure 5.1.f. Parts of the three-point hitch. Illustration by Jeff Mathison

Figure 5.1.g. 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 can lead to injury or fatality to the person standing nearby. Illustration by Jeff Mathison

Implement Hitching

Follow these steps for hitching to a drawbar (see also Task Sheet 5.2):

1. Position the tractor to align the hole in the drawbar with the hole in the implement hitch. This is called spotting. You may need to practice this skill.
2. Stop the engine, put the tractor in park, or set the brakes.
3. Attach the implement using the proper size 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 the appropriate task sheets on these tasks.

Follow these steps for hitching to a three-point hitch attachment (see also Task Sheet 5.3):

1. If clearance is needed, remove or reposition the tractor drawbar forward.
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, securely park the tractor, and set the brakes.
5. First attach left draft arm to the implement hitch point using the proper size hitch pin and security clip. The right arm is adjustable and 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 three-point hitch to the implement's upper hitch point. Raise the lift arms to lengthen or drive ahead with implement down to shorten to adjust 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 you cannot level the machine, ask for help.
8. Securely attach the upper hitch pin with the proper size hitch pin and security clip.

Figure 5.1.h. Heavy-duty quick-attach couplers are mounted on to the tractor's three-point hitch and can safely handle large three-point hitch implements without a person moving between the tractor and the implement. Refer to the owner's manual for additional instructions on their use or have a qualified operator demonstrate the correct procedure for using a quick-attach coupler. Credit: Jeff Mathison

Safety Activities

1. Practice backing a tractor with a drawbar to an implement to "spot" 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 to be a proficient tractor operator.
2. Practice backing a tractor with a three-point hitch to an implement to adjust the pin hole in the draft arms to the lower hitch pins on the implement's three-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 change of direction to be a proficient tractor operator.
3. On a tractor you can easily measure, take measurements and record the following:
   a. distance from ground to drawbar: _____ x _____ inches
   b. dimensions of drawbar (width and thickness): _____ x _____ inches
   c. hitch-pin hole opening in drawbar: _____ inches
   d. vertical distance from drawbar to center of PTO stub shaft: _____ inches

   How do these measurements compare with the standards shown on Table 5.1.a?
4. Using a battery-operated toy truck or tractor, devise a place to hitch a load at a point above the toy's axle. Make a sled from sheet metal or cardboard, and attempt to pull a load of small objects such as nuts, bolts, etc. What happens as the toy attempts to pull the load? Change the height and length of the angle of pull, and record the reaction of the toy truck or tractor to the changes made.

References

ANSI/ASABE, S482 Drawbars. American Society of Agricultural and Biological Engineers.

ANSI/ASABE, S217 Three-Point Free Link Attachment. American Society of Agricultural and Biological Engineers.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001

Using Drawbar Implements

Learning Goals

- Safely attach implements to a tractor's drawbar
- Safely use drawbar implements during transport, field use, turns, and backing operations

Related Task Sheets

- 4.10: Moving and Steering the Tractor
- 4.13: Using the Tractor Safely
- 4.14: Operating the Tractor on Public Roads
- 5.1: Connecting Implements to the Tractor

Introduction

Several agricultural implements are ground driven (the power comes from the wheels turning on the ground). Use of the PTO is unnecessary. The main connection is the drawbar. The beginning tractor operator is often assigned to hitch to and use these types of implements.

Operators must demonstrate how to safely use equipment. When connecting the implement to the tractor, the drawbar can push the implement to the rear, knock the jack stand over, or harm someone standing behind the implement.

This task sheet will focus on ground-driven towed equipment.

Hitching Review

Follow these steps for drawbar hitching to an implement equipped with a height positioning jack:

1. Back the tractor to the correct position to align, or "spot," the hole in the drawbar with the hole in the tongue (see Figure 5.2.a).
2. Stop the engine, securely park the tractor, 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, securely park the tractor, and set the brakes.
5. Attach the implement using the proper hitch pin and security clip, and move the jack to the transport position.

Hitching Safely

Backing a tractor in reverse to connect an implement presents crushing and runover hazards. Use a jack stand to support the implement and chocking blocks to keep the implement from rolling away. Practice backing the tractor to align the drawbar with the implement hitch or tongue.

Figure 5.2.a. 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 to position the implement tongue. Always chock the wheels of the implement. Credit: Jeff Mathison

Using Ground-Driven Machinery

Disks, harrows, hay rakes, windrow inverters, and older manure spreaders are a few of the ground-driven implements assigned to beginning tractor operators. Remember and follow these safety points when using them:

1. Make sure you know how wide the machine is 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 you begin field operations.
6. Allow plenty of space at ends of rows or fields to turn the equipment without "jackknifing."
7. Be sure to return the implement to the transport position before using public roads or passing through narrow farm gates.

Figure 5.2.b. If you need help hitching to a machine, insist that the helper stand off to the side of the operation. Many people have been crushed between tractors and machines while trying to help connect the machine to the tractor. This picture shows an unsafe act. Credit: Jeff Mathison

Figure 5.2.c. 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: Penn State Extension Ag Safety Team

If you have never used a particular implement, ask for a demonstration before you try the job.

Safety Activities

1. Practice spotting the tractor drawbar to the tongue of the implement so that you can hitch to a machine quickly and safely.
2. Demonstrate the safety procedures to use when backing a tractor to hitch a machine by showing a helper where to stand to safely help you spot the drawbar and implement tongue.
3. Inspect the ground-driven machines you may use to learn:
    a. How they are moved from transport to field position and vice versa
    b. What mechanism is used to engage the ground wheels with the turning parts of the machine
4. Check the machinery and tractors you may use for the hitch pins that will be used. Are they available, of the proper size, and have a securing clip? Where are the hitch pins stored on the farm?
5. Practice raising and lowering the various jack stands you find on agricultural equipment.

Resource

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Using Three-Point Hitch Implements

Practice hitching operations with the engine shut off and the tractor securely parked.

Learning Goals

- Safely connect a three-point hitch implement
- Safely use a three-point hitch implement
- Safely disconnect a three-point hitch implement

Related Task Sheets

- 4.9: Stopping and Dismounting the Tractor
- 4.10: Moving and Steering the Tractor
- 4.13: Using the Tractor Safely
- 4.14: Operating the Tractor on Public Roads
- 5.1: Connecting Implements to the Tractor
- 5.4: Making PTO Connections

Introduction

Once you can successfully connect an implement to a tractor's three-point hitch, you are 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). Operators must demonstrate how to safely use equipment.

This task sheet discusses both ground- and PTO-driven three-point hitch equipment.

Hitching Review

Follow these steps for safely connecting implements to a three-point hitch:

1. If needed remove the drawbar, or reposition the drawbar forward or to the side to provide clearance for the connection with the implement.
2. Back the tractor so the pin holes of the tractor's draft arms are nearly aligned with the implement's lower hitch pins (see Figure 5.3.a).
3. From the tractor seat and using the hydraulic lift controls, raise or lower the draft arms to match the implements lower hitch pins (see Figure 5.3.a).
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 (see Figure 5.3.c).
6. Remount and restart the tractor, and 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 three-point hitch to the top hitch point of the implement with the proper size pin and securing clip (see Figure 5.3.d). The upper link may need to be lengthened or shortened to fit. Ask for help if there is a problem you cannot solve.

Figure 5.3.a. Back slowly to the implement to be attached. Using the hydraulic controls, raise or lower the draft arms to nearly match the implement's lower hitch pins. Credit: Youth Work Guidelines

Figure 5.3.b. When connecting drawbar implements, never let a helper stand between the tractor and three-point hitch implement. Crushing injuries and death can result. Illustration by Jeff Mathison

Figure 5.3.c. 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 clip. Credit: Jeff Mathison

Figure 5.3.d. After adjusting the upper link of the tractor's three-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. (see Task Sheet 5.2). Credit: Jeff Mathison

Three-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 may be used. The PTO is the most common source of remote power. Three examples of PTO-driven implements include rotary mowers (bush hogs), fertilizer spreaders (spin spreader), and post hole diggers.

To attach the PTO shaft of a three-point hitch implement, follow these steps:

1. Connect the three-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 Task Sheet 5.4).
◊ Press the detent lock (see Figure 5.3.e) 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.

The three-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.

Figure 5.3.e. 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. See Task Sheet 5.4 for other forms of locking the PTO shaft. Credit: Jeff Mathison

Figure 5.3.f. To attach the PTO shaft, you will be operating in a crowded space. Be sure the tractor engine is shut off and securely parked. Credit: Jeff Mathison

Hitching Precautions for Three-Point Hitch Drawbars

Never pull a load with the three-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.

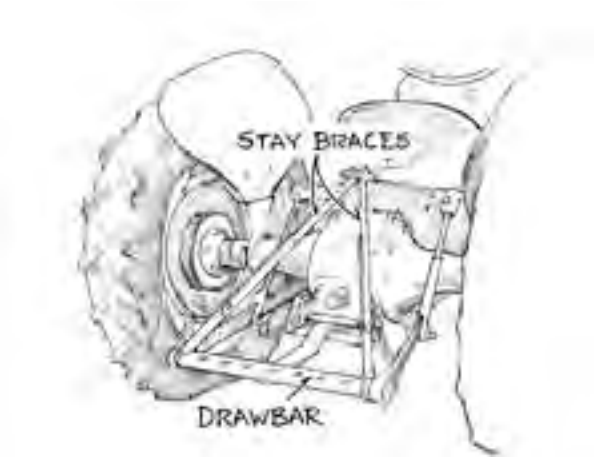

Figure 5.3.g. Stay braces prevent the three-point hitch drawbar from being lifted too high. Illustration by Jeff Mathison

Using the Three-Point Hitch Implement

Ground-driven three-point hitch implements are often assigned to the beginning tractor operator. A few ideas are presented here to help you safely operate these implements:

- ◊ Make sure you know how wide the machine is compared to the tractor.
- ◊ Be sure the machine is in the "transport" or "up" position for travel on public roadways.
- ◊ Lower the machine to the "field" position when you are ready to use it. This keeps the load pulling below the center of gravity.
- ◊ Engage the machine operation mechanism (levers, pins, etc.) for the wheels to power the machine if you are using a ground-driven machine. A qualified operator should demonstrate this procedure for each machine.
- ◊ Begin field operation of the machine by paying attention to field boundary fences and obstacles.
- ◊ Allow space at ends of rows or fields to lift the equipment with the three-point hydraulic lift.
- ◊ Do not make turns with a three-point hitch implement in or on the ground. This places undue force on the three-point hitch draft and lift arms, which can damage the machine.
- ◊ Backing a three-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 the direction you are going to prevent possible damage to the implement or three-point hitch draft and lift arms.
- ◊ Lift 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 5.3.h. If the three-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: Jeff Mathison

Figure 5.3.i. 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 three-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: Jeff Mathison

Lift the three-point hitch implement from contact with the ground before turning, backing, or transporting.

Safety Activities

1. Practice spotting the tractor three-point hitch draft arms to the three-point hitch attachment points of the implement for quick and safe hitching.
2. Demonstrate the rules you will use when backing a tractor to connect to a three-point hitch implement by showing your helpers where to stand to safely assist you in spotting the three-point hitch to the implement.
3. Inspect the ground-driven machines you may use to learn:
   a. How they are moved from transport to field position and vice versa, if applicable
   b. What mechanism is used to engage the ground wheels with the turning parts of the machine
4. Inspect all hitch pins and security clips on three-point hitch attachments. Did you find any problems or missing hitch pins?
5. Inspect a three-point hitch quick attaching coupler for cracks or damage to upper and lower lift hooks. Report any problems to your employer, mentor, leader, or instructor.

Resource

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Making PTO Connections

Learning Goal

◊ Attach the PTO driveline between the tractor and the implement

Related Task Sheets

◊ 2.3: Reaction Time
◊ 2.4: Age-Appropriate Tasks
◊ 3.1: Mechanical Hazards
◊ 5.3: Using Three-Point Hitch Implements
◊ 5.4.1: Using Power Take-Off Implements

Introduction

After spotting the hitch to connect the tractor to the implement, the operator may need to attach the PTO shaft of the tractor to the implement by way of the implement input driveline (IID). These connecting shafts can be heavy, greasy, and difficult to manipulate in the cramped space between the tractor and the equipment. Operators must have a strong grip and be able to work at an awkward angle. Check the Ag Youth Work Guidelines website to determine readiness to handle the task of PTO connection.

This task sheet discusses PTO design and how to make PTO connections through knowledge of that design.

PTO Stub Shaft Design

PTO Sizes

PTO stub shaft diameter for a 540-RPM shaft is 1⅜ inches. The 1,000-RPM stub shaft with 20 splines (teeth) has a diameter of 1¾ inches.

PTO Speeds

Tractor PTOs are designed to rotate at two common speeds, 540 RPM and 1000 RPM. Some 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 RPMs. A 540-RPM PTO shaft will have six splines (teeth). A 1,000-RPM PTO shaft may have 20 or 21 splines/teeth. The faster the PTO speed, the more teeth are used to make the PTO connection between the tractor and the implement.

540-RPM PTOs have six splines (or teeth). 1,000-RPM PTOs have 20 or 21 splines (or teeth).

Figure 5.4.a. The 540-RPM PTO stub shaft has six splines (teeth) and is 1⅜ inches in diameter. Credit: Jeff Mathison

Figure 5.4.b. The 1,000-RMP PTO stub shaft has either 20 splines (teeth) with a 1¾-inch diameter or 21 splines (teeth) with a 1⅜ -inch diameter. Credit: Jeff Mathison

Figure 5.4.c. Ag Youth Work Guidelines recommends that youthful farm workers wear snug-fitting clothes, nonskid shoes, and hearing protection while working around machinery. The youth's ability to lift and connect the PTO shaft must be evaluated by an adult who understands the physical development of children. Credit: Ag Youth Work Guidelines

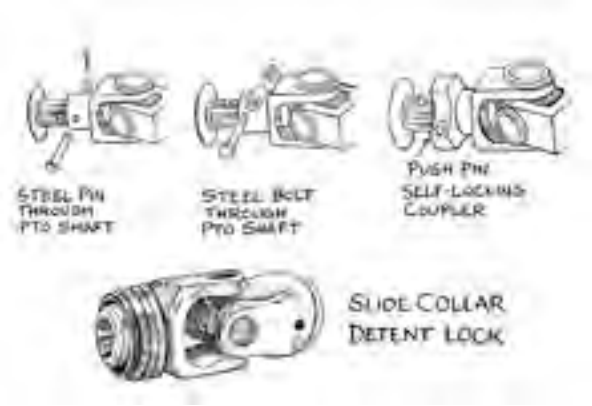

Figure 5.4.d. Various means to secure the PTO shaft to the stub shaft have been used over the years. Besides those connection methods shown above, another popular style is the sliding collar locking type shown in Figure 5.4.e. All types of locking device areas must be guarded as they are wrap points where the operator can become entangled in the PTO. Illustration by Jeff Mathison

Figure 5.4.e. The sliding collar lock on the PTO driveline has a metal collar that retracts. When the collar is released, springs force the collar forward and secure locking pins in the PTO stub shaft groove to secure it. A firm grip is needed to slide the collar. Credit: Jeff Mathison

PTOs must be guarded to prevent an entanglement hazard.

Connecting the PTO

Follow these steps to attach the PTO shaft of a three-point hitch implement:

1. Connect the tractor to the drawbar or to the three-point hitch of the implement using the approved steps (see Task Sheets 5.1, 5.2, and 5.3).
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. Have this procedure shown to you if necessary.

◊ Press the detent lock push pin inward (see Figure 5.4.e) as you slide the implement shaft onto the tractor stub shaft.

◊ Slide the implement shaft forward far enough to make sure the locking mechanism 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 that 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" to avoid placing extra strain on the universal joints. Many shafts are designed to prevent this from happening.

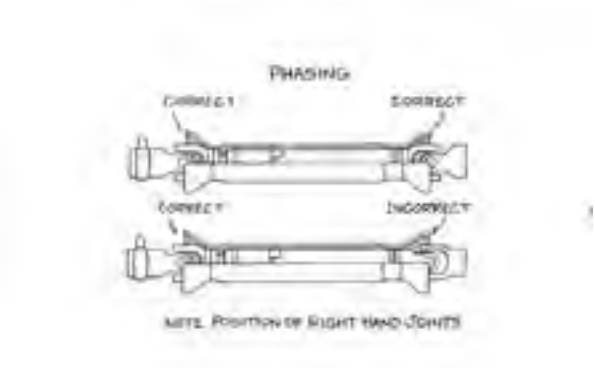

Figure 5.4.f. The upper portion of the drawing illustrates a correctly placed universal joint. You may wish to check the phasing on a PTO shaft. Illustration by Jeff Mathison

Ag Youth Work Guidelines

The Ag Youth Work Guidelines recommendations for connecting and disconnecting a PTO shaft are shown in this section. These recommendations were developed by a knowledgeable group of safety experts as a means of helping parents to match youthful agricultural workers with the tasks that are appropriate to their development. The PTO guidelines are presented below.

Adult Responsibilities:

◊ Ensure objects lifted are less than 25 percent of youth's body weight.

◊ Ensure implement is mechanically sound and safety features are in place.

◊ Demonstrate how to safely connect/ disconnect PTO, hydraulics, and other connections need for the task.

◊ Demonstrate proper lifting.

◊ Provide appropriate training.

◊ Ensure work area is free from as many hazards as possible

◊ Educate youth on avoiding/ addressing remaining hazards.

◊ Train youth to call adult in case of equipment malfunction.

The adult in charge should also evaluate you using the following questions:

1. Can the youth drive the tractor skillfully?
2. Can the youth hitch and unhitch implements?
3. Can the youth follow a 10-step process?
4. Does the youth demonstrate maturity and the ability to think through actions as well as consequences?
5. Does the youth recognize problems and demonstrate safe problem-solving responses?
6. Does the youth avoid loose clothing, clothing with strings, and ties back long hair for work?
7. Can the youth do the job four or five times under direct supervision?
8. Can an adult provide the recommended supervision?

Your experience level may be acceptable to you, but proof of your expertise should be evaluated by a qualified tractor operator.

Connecting a PTO shaft will be easier after practicing the job several times.

Figure 5.4.g. This is what the task of connecting a PTO 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. Continue practicing connecting a PTO on your own with supervision. Credit: Jeff Mathison

Figure 5.4.h. 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: Jeff Mathison

Safety Activities

1. Visit **www.cultivatesafety.org** and view the many guidelines presented for the various farm jobs you may be assigned to do. Are you ready to accept these jobs based upon the guidelines presented?
2. Do a survey of the tractors on a farm to determine how many have 540-RPM PTO shafts and how many have 1,000-RPM PTO shafts. Record the results.
3. Practice lifting a PTO shaft with your right hand while squeezing the locking mechanism of the PTO shaft connector. Practice lifting a PTO shaft with your left hand while squeezing the locking mechanism of the PTO shaft connector. From which side were you able to lift and squeeze best?
4. Check the phasing of 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 this drawing to show what was wrong.
5. Fill in the blanks:
   A. A PTO shaft with six teeth on the shaft is designed for _____ RPMs of speed.
   B. A PTO shaft that has 20 teeth on the shaft is designed for _____ RPMs of speed.
   C. A PTO shaft that has 21 teeth on the shaft is designed for _____ RPMs of speed.
   D. What is the maximum weight that a 14- or 15-year-old worker should be expected to lift without straining the back muscles?

      _____ percent of their body weight
6. Word scramble. Unscramble the following words. Then fill in the blanks to form a safety message about PTOs.

   _____ all PTO _____.

   d a u g r = _____

   s s t a r h = _____
7. From the phrase "implement input driveline," write a word list using as many letters as you can. The words must have at least four letters. No two-letter or three-letter words are permitted. Letters may only be used as many times as they appear in the phrase. Example: RIVET can be found in the phrase.

Resources

American Society of Agricultural and Biological Engineers, ANSI/ASABE, S203 Power Take Off.

Cultivate Safety website, www.cultivatesafety.org. National Farm Medicine Center and National Children's Center for Rural and Agricultural Health and Safety.

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Using Power Take-Off (PTO) Implements

Learning Goals

◊ Identify the components of a PTO system
◊ Identify the hazards involved with PTO use
◊ Develop safe habits when using a PTO

Related Task Sheets:

◊ 2.3: Reaction Time
◊ 3.1: Mechanical Hazards
◊ 5.4: Making PTO Connections

Introduction

The power take-off (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.

This task sheet discusses several aspects of PTO safety. Study this task sheet carefully.

The PTO is one of the oldest and most persistent hazards associated with farm machinery.

PTO Components

Figure 5.4.1.a. is a diagram of the components of an implement PTO system. Two typical PTO system arrangements are shown. The top drawing is of a PTO system involving a pedestal connection, such as one found on many types of towed implements (hay balers, forage choppers, large rotary mowers, etc.). The lower drawing is of a PTO system where 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. Without proper guarding, a serious threat to the operator's safety is created.

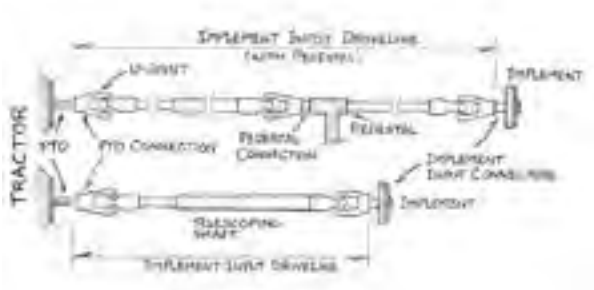

Figure 5.4.1.a. The major components of a PTO system. Illustration by Jeff Mathison

Figure 5.4.1.b. The major components of a PTO system found on the tractor. Credit: Michael Houtz, Penn State

PTO stub:

◊ Transfers power from the tractor to the machine
◊ Rotates at 540 RPM (9 times per second) or 1,000 RPM (16.6 times per second)

Master shield:

◊ Protects the operator from the PTO stub
◊ Is often damaged or removed and never replaced

PTO Entanglement Incidents

Incident data from 1970 to 2004 published by Beer, Deboy, and Field includes fatal and nonfatal injuries to youth involving agricultural drivelines. In general, PTO entanglements cases:

◊ Mostly involved youth ages 12 to 17 (55.7 percent)
◊ Involved the victim engaged in agricultural-work-related activity
◊ Involved entanglement that occurred in the primary driveline for 82.9 percent of the cases
◊ Occurred when shielding was absent or damaged
◊ Were at the PTO stub shaft and the implement input connection such as universal joints, spring-loaded push pins, shear pins, and protruding replacement bolts
◊ Involved stationary equipment, such as augers, elevators, or conveyors
◊ Occurred with the victim most commonly standing on the ground near the equipment

PTO Guards

Figure 5.4.1.c. The major guards of a PTO system. Credit: Jeff Mathison

Implement input connection (IIC) shield:

◊ Protects the operator from the IIC, including the implement input stub and the connection to the IID.

Safety chain:

◊ Keeps the integral journal shield from spinning
◊ Shows that the shield is not attached to the IID
◊ Should be replaced immediately if damaged or broken

Master shield: protects the operator from the PTO stub and the connection of the IID to the PTO stub.

Integral journal shield:

◊ Completely encloses the IID
◊ May be made of plastic or metal
◊ Mounted on bearings to allow it to spin freely from the IID
◊ Always check before operation for free movement

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:

- ◊ 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 your machine. Never switch drivelines among different machines.
- ◊ Position the tractor drawbar properly for each implement used. This will help prevent driveline stress and separation on uneven terrain and in tight turns. (See Task Sheet 5.1.)
- ◊ Reduce PTO shaft abuse by observing the following: avoid tight turns that pinch rotating shafts between the tractor and machine, keep excessive telescoping to a minimum, engage power to the shaft gradually, and avoid over tightening of slip clutches on PTO-driven machines.

If PTO guards are removed or damaged, they should be replaced immediately.

Figure 5.4.1.d. A lack of proper guards offers little to no protection from a spinning PTO shaft. Also notice the inadequate guarding of the universal joint near the PTO pedestal. Credit: Jeff Mathison

Safety Activities

1. Fill in the blanks in the following figure of the major components of a PTO system based on the information in this sheet.

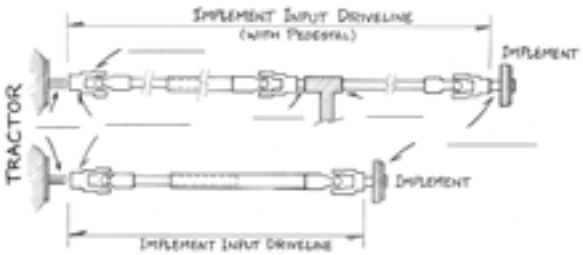

Illustration by Jeff Mathison

2. You are working with another tractor operator. He/she is sitting on the tractor seat and is 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 is 3 inches (d), and the operator can react by shutting off the PTO in 3 seconds.

   a. Find the circumference of the PTO shaft.

   Circumference = π d = 3.14 × 3 inches =

   _____ inches

b. How many times does the PTO shaft rotating at 540 revolutions per minute rotate in one second?

$$\frac{540 \text{ revolutions}}{1 \text{ minute}} \times \frac{1 \text{ minute}}{60 \text{ seconds}} =$$

$$\frac{540 \text{ revolutions}}{60 \text{ seconds}} \times \frac{\text{revolutions}}{\text{second}}$$

c. How many times does the PTO shaft rotate in 3 seconds?

Answer b × 3 seconds = _____ revolutions

d. How much shoelace will become wrapped up in the PTO in 3 seconds?

Answer a (in inches) × Answer c (in revolutions) = _____ inches of shoelace

References

Beer, S. R., G. R. Deboy, and W. E Field. "Analysis of 151 agricultural driveline-related incidents resulting in fatal and non-fatal injuries to U.S. children under age 18 from 1970 through 2004." *Journal of Agricultural Safety and Health* 13, no. 2 (2007):147–64. doi:10.13031/2013.22617.

Murphy, D. J. "Power-Take-Off (PTO) Safety." Penn State Extension, 2014. **extension.psu.edu/power-take-off-pto-safety**.

Implements with Hydraulic Components

Learning Goal

◊ Safely and correctly connect hydraulic components

Related Task Sheets

◊ 4.5: Tractor Controls
◊ 5.3: Using Three-Point Hitch Implements
◊ 5.4.1: Using Power Take-Off (PTO) Implements

Introduction

Hitching a machine to a tractor is the first process in using attached machinery. This allows the operator to use the tractor for transporting implements. In addition to the PTO shaft (Task Sheets 5.4 and 5.4.1), many components of implements also need power through hydraulic or electrical connections. Some may use a combination of both electrical and hydraulic.

This task sheet will help you understand and properly care for and use the hydraulic systems located on the tractor and used with the implement.

Hydraulic connector covers should be in place to keep out dust, dirt, grease, and moisture. Clean connections keep systems working longer.

Hydraulic Power

The hydraulic system uses an incompressible fluid, usually oil, under pressure to transmit forces from one component to another. The basic components of a tractor hydraulic system are shown in Figure 5.5.a. Note that the system is closed, meaning that the oil is designed to be contained within the system. Outside contaminates, such as dirt, water, or manure can damage the system. This is because hydraulic fluids work through systems with very small openings and are under great pressure. Any debris can plug or wear the components, resulting in system failure. Due to extreme high pressure and heat, users must observe several precautions.

A Simple Hydraulic System

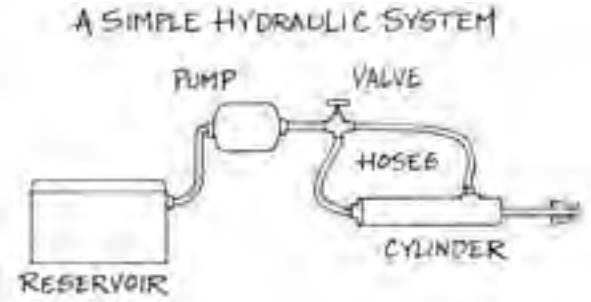

Figure 5.5.a. Hydraulic systems are closed systems that move and control fluid (hydraulic oil) for the purpose of operating cylinders and/or motors. This drawing gives a general look at hydraulic components. Much more detail is involved in these systems than this drawing shows. Filters, pressure relief valves, accumulators, etc., are included as well. Consult a machinery owner's manual to see drawings of more complex hydraulic systems. Illustration by Jeff Mathison

Precautions When Using Hydraulics

To safely and correctly operate hydraulic systems, understand these three points:

1. Clean oil needs
2. Heat generated by use
3. Oil leaks under pressure

Be sure you understand each point. If necessary, discuss these points with a knowledgeable farmer or mechanic.

Clean Oil Needs

Hydraulic pumps and control valves operate with clearances (tolerances) as small as 0.001 inch. Grit, grime, and dirt pushed through these openings 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 5.5.b. 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: Jeff Mathison

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 from friction builds. Under extreme load conditions, the reinforced hoses can become hot; however, metal connections, fittings, and piping can produce third-degree burns. Place the back of 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.

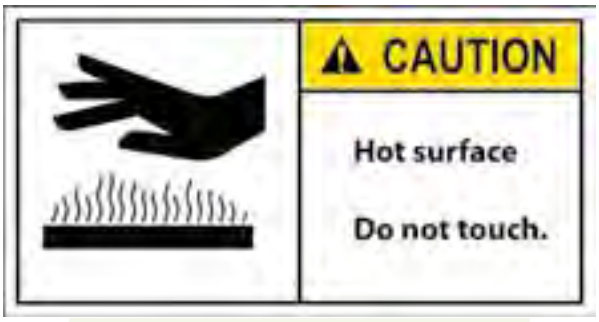

Figure 5.5.c. Hydraulic hoses and fittings can become hot during use. Place your hand near them to check for heating. Do not just grab them! Credit: Association of Equipment Managers

Wear safety glasses or a face shield and gloves when checking hydraulic systems.

High-Pressure Oil Leaks

Pressure within the hydraulic system can exceed 2,000 pounds per square inch (psi). Reinforced hoses develop pinhole leaks and hydraulic connections can vibrate loose.

Hydraulic leaks may be hard to see. Never check for these leaks with your hand. The high-pressure can inject oil droplets under your skin. Oil injected under your skin is a medical emergency and will require immediate medical care. Gangrene can occur, and limb amputation may be necessary.

Figure 5.5.d. 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 down time. Credit: Jeff Mathison

Figure 5.5.e. Use a mirror or piece of cardboard to check for high-pressure hydraulic leaks. Do not use your skin! Pinhole leaks are often invisible. Credit: Jeff Mathison

Hydraulic system pressure may exceed 2,000 psi. Pinhole leaks can develop.

Fittings and Connections

Figure 5.5.f. 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: Jeff Mathison

Figure 5.5.g. 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: Jeff Mathison

Connecting Hydraulic Hoses to Couplers

Hydraulic couplers make the connections quick and simple to use. Follow these steps:

1. Use a clean 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 (see Figure 5.5.h). Older style lock levers and manual pull lock rings may be also found. Ask for a demonstration of these.

If you cannot easily make the connection, try the following:

a. While seated on the tractor where no hydraulic lift arms or other moving parts can crush you, move the hydraulic control levers back and forth to release the static pressure. The previous operator may have failed to do this.
b. Move the locking ring of the female coupler back and forth to be sure that 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 result in the control valves/levers causing the opposite action of what is expected. This can lead to hazardous situations where 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 set-up, you should ask for help with determining which hose goes with which coupler.

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 hazardous situations to develop. A faulty repair may have created several problems that the beginning operator cannot solve.

Figure 5.5.h. The lock ring of the female end of the coupling will secure the two fittings together. A firm grip will be needed to insert the hydraulic hoses from the implement (male end) into the coupling on the tractor (female end). Credit: Jeff Mathison

Disconnecting Hydraulic Hoses

To disconnect hydraulic hoses:

◊ Relieve the static pressure
◊ 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

Safety Activities

1. On several different tractors, identify all the hydraulic system components that are external to the tractor. You can name the parts and their purpose to a friend or mentor.
2. To supplement your knowledge of the hydraulic systems components, examine a log splitter and identify all the hydraulic components. You can demonstrate the location, the name, and the function of each part to a friend or mentor.
3. Check the hydraulic fluid level of several tractors.
4. Practice connecting the hydraulic hoses to the tractor coupler.
5. Use the tractor hydraulic system for practice:
   a. Raising and lowering the three-point hitch arms
   b. Raising and lowering a high-lift bucket
   c. Tilting a high-lift bucket

Note: Ag Youth Work Guidelines recommends that only 16-year-old and older youth operate front-end loaders on tractors of greater than 20 horsepower.

6. What is the greatest source of damage to a hydraulic system?
   a. Water
   b. Dirt
   c. Air
   d. None of these
7. The term hydraulic refers to:
   a. Fluid under pressure
   b. Air under pressure
   c. Gas under pressure
8. Hydraulic pressures on farm equipment may exceed:
   a. 2,000 psi
   b. 4,000 psi
   c. 10,000 psi
9. The safe way to check for pin hole leaks in the hydraulic system is to:
   a. Rub your hand over the hose
   b. Hold a match near where you suspect the leak
   c. Hold a mirror or cardboard near where you suspect the leak

Resource

Cultivate Safety Safe Guidelines Search, **www.cultivatesafety.org/safety-guidelines-search/?category=familyyouth**.

Implements with Electrical Connections

Modern tractors and equipment rely on electrical accessories to get the job done efficiently.

Learning Goal

◊ Safely and correctly connect electrical components

Related Task Sheets

◊ 4.5: Tractor Controls
◊ 5.2: Using Drawbar Implements
◊ 5.3: Using Three-Point Hitch Implements

Introduction

Hitching a machine to a tractor is the first process in using attached machinery. This allows the operator to use the tractor for transporting implements. In addition to the PTO shaft (see Task Sheets 5.4 and 5.4.1), many components of implements also need power through hydraulic or electrical connections. Some may use a combination of both electrical and hydraulic power.

This task sheet will help you understand and properly care for and use the electrical systems located on the tractor and used with the implement.

Electrical Components

Modern farm implements come equipped with many features that need electrical power.

Lights are added to implements to allow for nighttime field operation, provide lighting for nighttime repair work, and to serve as warning signals during public roadway transport.

Electrical sensors are used to measure equipment operation functions and can stop the implement if problems exist.

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. The planter may not be dropping seeds due to a plugged seed drop tube.

Warning devices can be activated by using the reverse gear, which sounds an alarm while backing the tractor and implement. Horns and flashing lights also serve to warn bystanders of your actions.

Convenience outlets that use a wiring harness permit connection of a trailer or wagon for proper lighting during public road use.

Figure 5.6.a. Electrical connectors are protected from dust, dirt, grease, and grime with dust caps. Keep these covers repaired and in place to ensure electrical connections can be made without delay. Credit: Penn State Extension Ag Safety Team

Using Electrical Connections

To properly care for and use electrical connections, follow these instructions:

- ◊ 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 or you may damage them.
- ◊ Grip the connector body 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.

Figure 5.6.b. Grip the connector body to disconnect the wiring harness. Do not pull on the wires themselves. Become familiar with other connector styles before disconnecting them. Credit: Penn State Extension Ag Safety Team

Figure 5.6.c. 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: Jeff Mathison

Be sure the electrical cables cannot be caught or pinched by hydraulic lift arms or moving parts of the equipment.

Safety Activities

1. Practice connecting electrical wiring harnesses together to get the feel of how easily the connection can be made.
2. Examine several tractor and implements to learn the positions of electrical connections and control switches or knobs that activate the circuits they connect.
3. Locate operator's manuals to learn more about machinery monitors, crop sensors, and remote lighting features of a machine.
4. Ask a qualified tractor operator to demonstrate a tractor's electrical components for you.

Reference

Electronic and Electrical Systems, Fundamentals of Service. John Deere Publishing, 2005.

6

Section Six
Materials Handling Equipment

Skid Steers

Learning Goal

◊ Safely use a skid steer loader

Related Task Sheets

◊ 2.8: Hazard Warning Signs
◊ 2.9: Hand Signals
◊ 3.1: Mechanical Hazards
◊ 3.2: Noise Hazards and Hearing Protection
◊ 4.2 Tractor Hazards
◊ 4.6: Preventive Maintenance and Pre-Operation Checks
◊ 4.7: Starting and Stopping Diesel and Gasoline Engines
◊ 4.12: Tractor Stability
◊ 4.13: Using the Tractor Safely
◊ 5.5: Implements with Hydraulic Components

Introduction

Skid steer loaders are versatile machines. They fit into small spaces and can turn within a tight radius, and controls can be learned quickly. Many farm workers may accomplish a variety of tasks using a skid steer loader.

This task sheet discusses the safe use of a skid steer loader. Skid steer loaders are safe to use if the operator works within the machine's limitations. As with all machinery use, the operator must know the machine's proper use and limitations.

Skid Steer Loader Basics

Skid steer loaders get their name by the method of steering. The wheels are fixed in a straight line relative to the body of the machine. By spinning the left and right wheel pairs at different speeds, the machine turns by skidding, or dragging its wheels across the ground. Skid steer loaders are equipped with lift arms used with attachments. The most common attachment for these machines is the bucket.

Skid steer loaders can be used for scraping corrals, moving bedding material, loading trailers, or even snow removal.

This machine uses internal combustion engine to power hydraulics that operate the attachments.

Figure 6.1.a. Skid steers are controlled by hand levers or joy sticks. Push the levers forward to travel forward; pull back to go in reverse. Let go to stop. The levers also steer the machine. Credit: Agricultural Youth Work Guidelines

Hydraulic Power

A hydrostatic transmission controls forward and reverse direction. Hydrostatic valves control the flow of hydraulic oil to steer the machine. Hydraulic cylinders raise and lower lift arms and tilt the load bucket. See Task Sheet 5.5 for a review of hydraulic power.

Hydraulics produce high power and forces in small volumes, meaning the machine moves the instant you move the control levers or pedals. The skid steer will move forward, reverse, or "skid" steer.

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. Operators 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 overturn.

Machine Hazards

Skid steer loaders 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, and a parking brake are arranged compactly within the operator's space. It is easy to bump 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.

Over 50 percent 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 maintenance inspection of the machine. Check the oil level, tire pressure, coolant level, and fuel. Refer to the operator's manual for specific instructions and locations of each.

Entering and Exiting the Skid Steer

Before entering the machine, observe the following points:

- ◊ 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. Once seated, lower the restraint bar and/or fasten the seat belt immediately. Exit the machine using three points of contact while facing the operator's station.

Controls

Before using the skid steer, become familiar with the controls. A qualified person should demonstrate how to start and stop the engine,

move the machine forward and reverse, steer the skid steer, and raise, lower, and tilt the bucket attachment. It is a good idea to know 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.

Skid steer loaders are controlled by hand levers and foot pedals. 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 will make the skid steer turn 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 6.1.b. and "Using the Lift Arm and Load Bucket Pedals" below for more details.

Joystick controls are also used to control the functions of the skid steer. Read the operator's instruction manual and request a demonstration on their use.

Use both hands and both feet to control the skid steer's work.

Figure 6.1.b. The 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 arms. 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. Illustration by Jeff Mathison

Using the Lift Arm and Load Bucket Pedals

Foot pedals on the skid steer are used to control the high lift (boom) work of the skid steer. Toe and heel movements are needed to activate these controls (see Figure 6.1.b). Note: Some models use the hand controls to make these movements. These movements must be done smoothly. Hard-soled shoes give better feel for the pressure needed on the pedal.

Raising the Lift Arms (Left Pedal)

The left pedal raises or lowers the lift arm (boom). Use the left heel to push on the back of the pedal to raise the lift arms and bucket. Use the left toes to push on the front of the pedal to lower the bucket.

Tilting the Bucket (Right Pedal)

The right pedal controls the load bucket. Use the right heel to push on the back of the pedal to roll the bucket back while loading. Use the right toes to push on the front of the pedal to dump the bucket while unloading.

Some skid steer models use hand controls (joystick-type) to raise and lower the lift arms and to tilt the load bucket.

Skid Steer Safety

Skid steer loaders can work in small areas, but they have similar limitations as does a tractor. Follow these skid steer safety recommendations:

- ◊ One seat and one seat belt means one operator. No passengers are permitted on the bucket.
- ◊ Lower the safety restraint bar and/or fasten the seat belt every time you enter the machine.
- ◊ Be sure the area around the skid steer is clear of children, bystanders, pets, and livestock.
- ◊ 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 that capacity with a lifted load will result in forward or sideways tipping of the machine. See Figure 6.1.c.
- ◊ 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. See Figure 6.1.d.
- ◊ Avoid crossing steep slopes.
- ◊ Avoid ditches and stream banks to prevent overturns.
- ◊ Lower the boom and bucket, stop the engine, and set the park brake before dismounting the machine. Do this every time.
- ◊ Never stand or lean where lift arms or load bucket movements could crush you.
- ◊ 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.

Safety Activities

1. Use the Internet to visit manufacturers' websites (John Deere, New Holland, Bobcat, etc.). Assemble a picture chart of as many skid steer loader attachments as you can find.
2. Set up a skid steer loader course to practice moving the skid steer around and through obstacles. Be sure that one part of the obstacle course involves using the load bucket.
3. With adult supervision and a blind fold (skid steer parked and brakes locked), raise and lower the lift (boom) arms and tilt and roll the bucket as the supervisor commands you. You must be able to use the proper controls to operate the skid steer without errors.
4. Match the skid steer control position with the resulting action to be expected.

   Skid steer control position

   ___A. Left foot pedal pushed forward with toes
   ___B. Left foot pedal pushed downward with heel
   ___C. Right foot pedal pushed forward with toes
   ___D. Right foot pedal pushed downward with heel
   ___E. Right hand control lever pushed fully forward, left hand control lever pulled fully back
   ___F. Right hand control lever pulled backward, left hand control lever pulled back

   Resulting action to be expected

   1. Skid steer spins in circles to the left
   2. Lift arm raises
   3. Bucket tilts forward to unload
   4. Bucket rolls back to load
   5. Lift arm lowers
   6. Skid steer moves forward
   7. Skid steer moves in reverse

5. Determine how the joystick-controlled skid steer performs the functions in Question 4.

Figure 6.1.c. Skid steer loaders can tip forward if overloaded. This is an important reason to wear the seat belt and understand the skid loader's load limitations. Illustration by Jeff Mathison

Figure 6.1.d. 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. Illustration by Jeff Mathison

Resources

"Preventing Injuries and Deaths from Skid Steer Loaders." National Institute for Occupational Safety and Health. **https://www.cdc.gov/niosh/docs/98-117/default.html**.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Starting and Stopping a Skid Steer

Learning Goal

◊ Safely start and stop the skid steer

Related Task Sheets

◊ 4.7: Starting and Stopping Diesel and Gasoline Engines
◊ 6.1: Skid Steers

Introduction

Manufacturers warn that operators must have instruction before running a skid steer. It is important to ask questions, get training, and read the operator's manual. The supervisor should demonstrate the controls and allow you to practice them before determining if you are ready for the task. Untrained operators can cause an injury, fatality, and property damage.

This task sheet will help you understand how to safely start and stop a skid steer.

Interlock Control System

Skid steers are equipped with an interlock system, meaning the skid steer cannot be started unless the operator is physically in position to operate the machine. The machine cannot be started and operated except from the seat with the seat belt fastened.

The seat belt and the operator restraint allow the lift, tilt, and traction functions of the skid steer to be activated. All of these functions are electronically interlocked with the start function. A lighted display on the instrument panel will indicate if these systems are functional.

Figure 6.1.1.a. When the operator is seated in the skid steer seat with seat belt fastened or operator restraint bar in place, the instrument panel lights will indicate that system functions are ready to use. Credit: Penn State Extension Ag Safety Team

You should see the lighted display for:

◊ Seat occupied/seat belt fastened/operator restraint bar
◊ Valve for lift and tilt functions
◊ Traction function (forward/ reverse)
◊ Power to input controller supplied (the input controller provides power to all output functions electronically)

The owner or the operator should not attempt to disable the interlock system.

Become familiar with all parts of the instrument panel.

Start Procedure

Use the bucket or attachment steps, grab handles, and safety treads to get on and off the skid steer. Always maintain three points of contact and face the machine as you climb onto the skid steer.

Follow these steps to start:

1. Adjust seat position.
2. Fasten seat belt snugly or lower seat bar if so equipped.
3. Check that foot pedals and hand controls are in a neutral position.
4. Set engine speed control to a half-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 five minutes in cold weather.

Stopping the Skid Steer

Stopping the engine may require additional steps besides 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 shutdown. Your supervisor should have this information readily available.

To stop the skid steer:

1. Idle back the engine speed to half throttle.
2. Set the parking brake.
3. Return lift arms and attachments to ground level.
4. If attachments with hydraulic hoses are to be changed, relieve the pressure in the auxiliary hydraulic system by either turning the ignition key past stop for a few seconds until the engine is stopped or moving the hydraulic control lever back and forth several times after the engine is stopped. This will make the Quick Couplers® easier to disconnect and connect.
5. Turn the ignition key to "OFF."
6. Remove the key, if required.
7. Raise seat bar or remove seat belt, and dismount the machine using the grab handles while facing the machine. Maintain three points of contact as you exit the machine.

Figure 6.1.1.b. When shutting down the machine, return the lift arm and skid steer attachments to ground level. Lowering the attachment makes it safer for the operator to exit the cab. Credit: Jeff Mathison

Ask the supervisor if there are additional shutdown requirements that should be followed.

Safety Activities

1. If you have never operated a skid steer, visit an equipment dealership and ask to sit in the skid steer cab to observe what controls are available and where they are located. This may be done with your employer's guidance as well.
2. Use 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.
3. Practice starting and shutting off the skid steer and using the lift and traction controls while sitting in the machine with the parking brake set.
4. Learn where the lift arm locking pins are located on the skid steer.
5. Ask a classmate to describe the conditions that must be met for an operator to exit the skid steer cab.

Resources

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

"Skid Steer Safety for Farm and Landscape." Penn State Extension. **extension.psu.edu/skid-steer-safety-for-farm-and-landscape**.

HOSTA Task Sheet 6.1.2

Skid Steer—Ground Movement

Learning Goal

◊ Safely steer the skid steer in the direction you must travel

Related Task Sheet

◊ 6.1: Skid Steers

Introduction

The skid steer is steered by skidding the inside tires or rubber track while the outside drive wheels or track move the machine in the direction of the skid. On soft soil or in a manure-packed barn area, this happens easily. On a hard surface like a roadway, the machine may grab the hard surface and bounce roughly.

This task sheet discusses safe and efficient ground movement of a skid steer. This includes moving it without damage to the machine, bystanders, or property.

Forward, Back, Turn

Control levers function to steer and engage ground movement of a skid steer. Some skid steers use two levers (Figure 6.1.2.a.), while others may use a "joystick" type of control. Refer to the operator's manual and become familiar with the controls that you will be using.

Figure 6.1.2.a. 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: Jeff Mathison

To use control levers to move the skid steer forward or reverse:

◊ Push forward on both levers to go forward.
◊ Pull both levers toward you to go in reverse.
◊ Push forward on the left lever and pull back on the right lever to turn to the right.
◊ Push forward on the right lever and pull back on the left lever to turn to the left.

Note: Ensure the throttle is positioned so that the engine speed is 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. Joysticks can control 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 function (Figure 6.1.2.b). In some cases, there may be dual functions for the joystick depending on the mode of use selected.

Study the operation symbols or ask your supervisor to explain how the joystick or any other component you do not understand is used.

Figure 6.1.2.b. Joystick controls reduce operator fatigue. The joystick can be rotated to many positions and has fingertip button controls to move the skid steer, raise/lower lift arms, tip the bucket, and operate hydraulic-powered accessories. Credit: Jeff Mathison

Let go of the skid steer control levers to return to a neutral position and stop moving.

Safety Considerations

Operator vision is reduced once in the cab of the skid steer. There are blind spots to the side and the rear of the machine. While 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 that let you see behind you.

Skid steers are not made for rough terrain work. When operating on sloping ground:

- ◊ Drive slowly.
- ◊ Keep the bucket as low to the ground as possible.
- ◊ Load the bucket evenly.

If you must move the skid steer over a sloped area, follow these safe practices:

- ◊ Avoid crossing steep slopes.
- ◊ Keep the heaviest weight up the hill whether traveling up or down the hill. For example, with an empty bucket, back up the hill; with a full bucket, drive forward up the hill (see Figure 6.1.2.c).
- ◊ Stay away from ditches, stream banks, and silage pile edges to prevent an overturn.

Figure 6.1.2.c. Do not cross steep slopes, but travel up or down the slope with the heaviest part of the load carried toward the top of the hill. Illustration by Jeff Mathison

A reverse alarm or backup camera can help make backing the skid steer safer.

Safety Activities

1. Set up a skid steer loader course to practice moving the skid steer around and through obstacles. Do this in forward and reverse. Include using the loaded bucket as part of the course.
2. Inspect the work area 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 your moving the skid steer as you work.
3. Have an operator sit in the skid steer facing forward; approach the skid steer from different angles, asking the operator to signal when they can see you coming. Mark these positions 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 could be the results if a small child, pet, or bystander entered that area as you operated the skid steer?

Resources

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

"Suggestions for Skid Steer Safety." Penn State Extension. **extension.psu.edu/suggestions-for-skid-steer-safety**.

Skid Steer—Attaching Accessories

Learning Goal

◊ Safely attach skid steer attachments

Related Task Sheets

◊ 5.5: Implements with Hydraulic Components
◊ 6.1: Skid Steers

Introduction

The skid steer is commonly equipped with a bucket to move soil, gravel, feed, and more. At times other jobs will require the attachment be changed to either a pallet fork, post hole auger, soil preparation tool, or powered broom. You should be familiar with how to change these accessories.

This task sheet will discuss the skid steer quick attachment procedures and how to do this important job safely.

Know the Parts

Attachments require a locking mechanism to secure them to the boom. The parts of the system include:

◊ Pivoting mounting plate attached to the boom lift arms
◊ Latch handles to lock the attachment to the pivoting mounting plate
◊ Attachment saddle (part of the attachment)

How to Do It

To mount an attachment, 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.

Reverse the process to remove the attachment. When attachment is free, lower the boom slightly and slowly back away from the attachment. Be sure the attachment is sitting in a stable position.

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 6.1.3.a. 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: Jeff Mathison

Figure 6.1.3.b. 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 the hydraulic control that activates the lock pin. Credit: Jeff Mathison

Do not attempt to lock the manual lock pins from inside the operator's cab. Keep all body parts inside the cab.

Removing a Hydraulic-Powered Attachment

Removing an attachment that is hydraulically powered involves not only the mechanical connection but also the hydraulic hoses. Follow these steps to disconnect the hydraulic hoses:

- ◊ Make sure the attachment is in a stable position before disconnecting the mechanical linkage and hydraulic connectors.
- ◊ With the lift boom arms lowered, move the hydraulic control levers back and forth a few times to release the static (load) pressure.
- ◊ Push back on the lock ring.
- ◊ Remove the hydraulic hoses from the couplings.
- ◊ Replace the dust caps on each connector.
- ◊ Hang the hoses on the equipment.
- ◊ Keep the hoses off the ground.

If you are not sure of these steps, seek assistance to prevent damage to the machine or injury to yourself.

Figure 6.1.3.c. A hydraulically operated tiller attachment is shown. Credit: Jeff Mathison

Figure 6.1.3.d. Hydraulic hoses are attached to the skid steer at conveniently located quick connection points. Credit: Jeff Mathison

Don't forget to remove the hydraulic lines before pulling away.

Safety Activities

1. Ask your supervisor to demonstrate how the bucket attachment is removed and replaced on the skid steer.
2. Practice removing and reattaching the skid steer load bucket or other attachment being used. Pay special attention to the lower bucket tabs where the lock pins hold the bucket/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 attachments lower tabs.

HOSTA Task Sheet 6.1.4

Skid Steer—Using Hydraulic System Attachments

Learning Goal

◊ Safely and correctly connect and use the skid steer hydraulically operated machine attachments

Related Task Sheets

◊ 5.5: Using Implements with Hydraulic Components
◊ 6.1: Skid Steers
◊ 6.1.3: Skid Steer—Attaching Accessories

Introduction

The skid steer is a hydraulic machine powered by an engine. Everything that happens when you start the engine is a hydraulic action for ground movement, steering, lift arm control, bucket position, or attachment operation.

This task sheet will help you understand and properly care for and use the skid steer and the hydraulically operated attachments you may encounter.

Hydraulic Power

The term "hydraulic" refers to fluids under pressure. Hydraulic oil is the common fluid used with farm equipment. The basic components of the hydraulic system are shown in Figure 6.1.4.a. Hydraulic fluids work through systems with very small openings and are under great pressure.

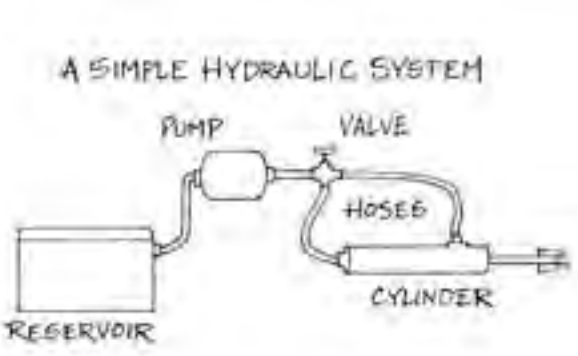

Figure 6.1.4.a. Hydraulic systems are closed systems that move and control fluid (hydraulic oil) for the purpose of operating cylinders and/or motors. This drawing gives a general look at hydraulic components. Much more detail is involved in these systems than this drawing shows. Filters, pressure relief valves, accumulators, etc., are included as well. Consult a machinery owner's manual to see drawings of more complex hydraulic systems. Illustration by Jeff Mathison

Precautions When Using Hydraulics

To safely and correctly operate hydraulic systems, understand these three points:

◊ Oil needs to be clean.
◊ Heat is generated by use.
◊ Oil leaks under pressure.

Be sure you understand each point. If necessary, discuss these points with a knowledgeable supervisor or hydraulic technician.

Clean Oil Needs

Hydraulic pumps and control valves operate with precise clearances and close tolerances. Grit, grime, and dirt pushed through these openings 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.

Hydraulic connector covers should be in place to keep out dust, dirt, grease, and moisture. Clean connections keep systems working longer.

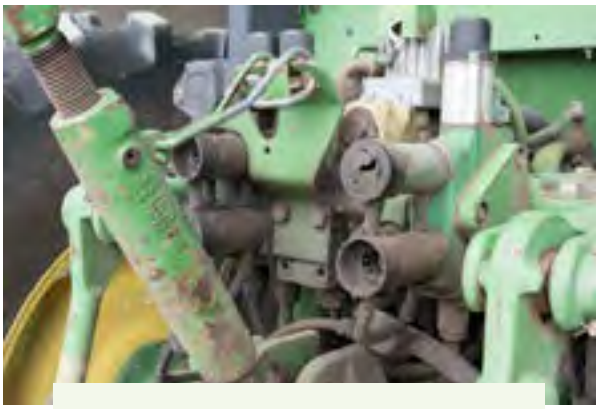

Figure 6.1.4.b. Missing hydraulic connection covers signify a problem in this picture. Credit: Jeff Mathison

Hazards from Heat Generated by Use

As hydraulic fluid moves through the closed system, the fluid meets resistance from the load to be lifted or moved. Pressure increases and heat in the lines and hydraulic controls builds. Under extreme load conditions, the reinforced hoses can become hot, but metal connections, fittings, and piping can become super-heated.

Place the back of 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 connections.

High-Pressure Oil Leaks

Pressure within the hydraulic system can exceed 2,000 pounds per square inch (psi). Reinforced hoses can develop pinhole leaks and hydraulic connections can vibrate loose, allowing oil to leak from the system.

Hydraulic leaks may be hard to see. Never check for these leaks with your hand; use a mirror or piece of cardboard. The high pressure can inject oil droplets under your skin. Oil injected under your skin is a medical emergency and will require immediate medical care. Gangrene can occur, and limb amputation may be necessary.

Hydraulic system pressure may exceed 2,000 psi. Pinhole leaks can develop.

Figure 6.1.4.c. Hydraulic hoses may be reinforced, but damage to the outer covering plus pin holes from high pressure can cause serious injury (e.g., amputation) and machinery down time. Credit: Penn State Extension Ag Safety Team

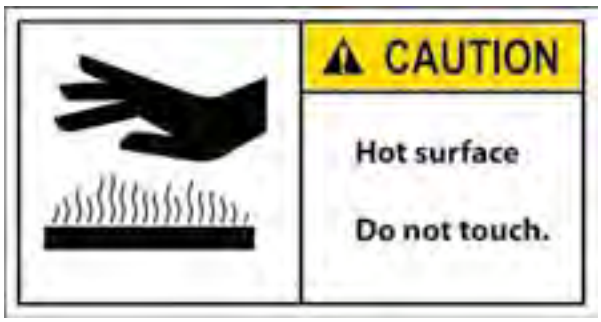

Figure 6.1.4.d. Hydraulic hoses and fittings can become hot during use. Place your hand near them to check for heating. Do not just grab them! Credit: Association of Equipment Managers

Figure 6.1.4.e. Use a mirror or piece of cardboard to check for high-pressure hydraulic leaks. Do not use your hand! Pinhole leaks are often invisible. Credit: Penn State Extension Ag Safety Team

Fittings and Connections

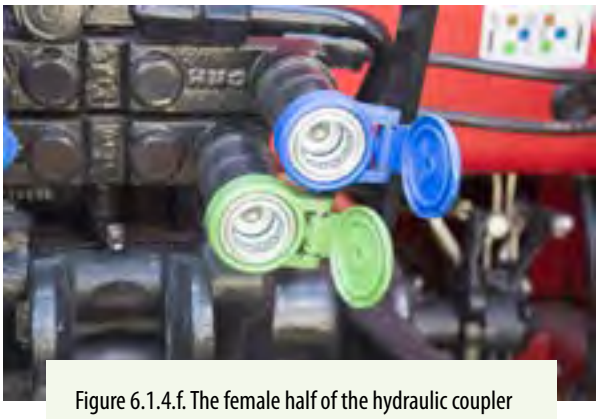

Figure 6.1.4.f. The female half of the hydraulic coupler is considered to be part of the skid steer. Dust covers protect the quick-release fitting, which includes the lock ring. Credit: Jeff Mathison

Figure 6.1.4.g. 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: Jeff Mathison

Connecting Hydraulic Hoses to Couplers

Hydraulic couplers make the connections quick and simple. 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. Older lock levers and manual pull lock rings may be also found. Ask for a demonstration of these connectors.

If you cannot easily make the connection, try the following:

a. While seated on the skid steer where no hydraulic lift arms or other moving parts can crush you, move the hydraulic control levers back and forth to release any static pressure. The previous operator may have failed to do this.
b. Move the locking ring of the female coupler back and forth to be sure that 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 result in the control valves/levers causing the opposite action of what is expected. This can lead to hazardous situations where 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, you may find that you must ask for help to determine which hose goes to which coupler.

Hydraulic systems 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 hazardous situations to develop.

Someone's faulty repairs may have created several problems that the beginning operator cannot solve.

Figure 6.1.4.h. The lock ring of the female end of the coupling will secure the two fittings together. Credit: Penn State Extension Ag Safety Team

Disconnecting Hydraulic Hoses

To disconnect hydraulic hoses:

- ◊ Relieve the static pressure by moving the control lever.
- ◊ 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.

Figure 6.1.4.i. A firm grip will be needed to insert the hydraulic hoses from the implement (male end) into the coupling on the tractor (female end). Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Identify all the hydraulic system components that are external to the skid steer. You may wish to name the parts and their purpose to a friend or mentor or supervisor.
2. Check the hydraulic fluid level of a skid steer. Could you find where to check the fluid level? If not, use the operator's manual to find the location of the hydraulic fluid fill and/or check point.
3. Practice connecting the hydraulic hoses to the skid steer coupler until you can do this easily.
4. Use the skid steer hydraulic system to practice:
   a. Raising and lowering the lift arms
   b. Tipping the bucket forward and rolling it back
5. What is the greatest source of damage to a hydraulic system?
   a. Water
   b. Dirt
   c. Air
   d. None of these
6. The term hydraulic refers to:
   a. Fluid under pressure
   b. Air under pressure
   c. Gas under pressure

7. Hydraulic pressures on skid steers and attachments may exceed:
    a. 2,000 psi
    b. 4,000 psi
    c. 10,000 psi
8. The safe way to check for pin hole leaks in the hydraulic system is to:
    a. Rub your hand over the hose
    b. Hold a match near where you suspect the leak
    c. Hold a piece of metal or cardboard near where you suspect the leak

Off-Highway Vehicles

Learning Goal

◊ Safely use ATVs and utility vehicles for work and recreational purposes

Related Task Sheets

◊ 2.1: Injuries Involving Youth
◊ 2.4: Age-Appropriate Tasks
◊ 4.13: Using the Tractor Safely
◊ 6.1: Skid Steers

Introduction

All-terrain vehicles (ATVs), recreational off-highway vehicles, and utility task vehicles are three subsets of the broad term "off-highway vehicles." These vehicles are widely used for both recreation and work. These machines are associated with numerous injuries and deaths.

Every year, approximately 100,000 injuries and 650 deaths involve ATVs. The U.S. Consumer Product Safety Commission reports that one in four people treated in hospital emergency rooms are younger than age 16.

This task sheet discusses safe use of off-highway vehicles as they are used for work and recreational purposes.

All-Terrain Vehicles

As the name implies, all-terrain vehicles (ATVs), also known as quad bikes or four-wheelers, are designed for off-road terrain. Sportsmen, leisure time enthusiasts, and farm workers use ATVs in areas where access limits the use of larger vehicles.

Most ATVs are designed for one rider, and the following features must be considered before operating:

◊ **Stability.** A four-wheel ATV has a narrow wheelbase and relatively low center of gravity. However, heavy loads, steep slopes, and "popping the clutch" can cause the ATV to roll or flip backward. Overturns occur with operator actions that raise the center of gravity. A 200-pound operator is approximately 33 percent of the weight of a 600-pound ATV. Shifts in the body position of the operator have a big impact on the stability of the ATV. Note: Three-wheeler sales have been banned for several years.

◊ **Suspension.** ATVs can bounce and pitch sideways at high speeds. Coil springs and shock absorbers are used to improve suspension and steering control. Rear axle suspension may come as independent or fixed axle. Independent rear axle suspension allows the rear wheels to operate independently to accommodate variations in rough terrain; this provides a smoother ride for the operator.

◊ **Drive lines.** 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 overturns if the drive wheels are locked together for traction.

◊ **Power and speed.** ATV engines vary in size from 100cc to 700cc or greater. Transmission gear ratios also vary. 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.

Figure 6.2.a. A four-wheeler, or ATV, can be used for many purposes. Respect the ATV for the powerful machine it is. Credit: Jeff Mathison

Figure 6.2.b. 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 supervisor should work with you to help you learn how to work safely with an ATV. Credit: Agricultural Youth Work Guidelines

ATV Operation and Safety

Safety training for ATV use is the first step in being a qualified ATV operator. Local ATV dealers, ATV 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. Use the operator's manual and the safety warning labels on the ATV to help educate yourself before using the machine.

Here are some guidelines for safe ATV use:

◊ Manufacturers recommend that ATVs with engine sizes greater than 70cc be sold only for children 12 and older and that ATVs with engines greater than 90cc be sold only for individuals 16 and older. The child's strength, skills, and maturity determine readiness to operate an ATV.

◊ Carrying passengers increases the risk of overturns, injury, and death. A second person changes the center of gravity of the machine and the machine's steering ability.

◊ Know the machine's limitations. Operating on steep terrain, pulling heavy loads, excessive speed, and "wheelie" type starts can result in ATV overturn.

◊ Wear a full-face shield helmet. The helmet should fit snugly and securely. It should be labeled with the Department of Transportation (DOT) and/or American National Standards Institute (ANSI) 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 Z87.1 label.

◊ Over-the-ankle shoes with sturdy heels and soles are necessary.

◊ Gloves and shirts with long sleeves are needed for specific jobs

- ◊ Use lights, reflectors, and highly visible flags to increase the ATV's visibility.
- ◊ Avoid public roads. Paved and unpaved roads are designed for truck and automotive traffic. ATVs are designed for off-road use. Increased risk for rollovers of ATVs on road surfaces has been shown.
- ◊ Check your 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 in your state.

Injury from ATV use most often occurs because of extra passengers, excessive speed, and road travel.

Utility Task Vehicles

Utility task vehicles (UTVs) are similar to ATVs except they are fitted with cargo boxes to carry work material. Most will feature seating for two riders in a side-by-side arrangement. This vehicle can have four, five, or six wheels depending on its use. The UTV weighs about 1,000 pounds and can carry several hundred pounds of cargo. The machine's engine may use diesel, gasoline, or electric.

Like other farm machines, the UTV is made for work purposes. Hauling feed, mulch materials, and supplies makes it a convenient transport for small jobs. Like an ATV, the utility vehicle is a tool and not a toy.

Safe operation of the utility vehicle requires the same safe work habits as used with tractors, skid steer loaders, and ATVs.

Figure 6.2.c. UTVs are versatile, allowing operators to do the smaller jobs that a pickup truck may be unsuited to do. Remember that the utility vehicle has limitations. Overloading, shifting loads, and sharp braking can cause turnovers. Credit: Jeff Mathison

Safe UTV Use

Use the operator's manual and safety signs/decals found on the machine to learn how the UTV operates and what safety practices to observe. A successful operator becomes familiar with a machine before attempting to use it. Ask a qualified operator to show you what to do if no training materials can be found.

The following safety practices should be followed in operating a utility vehicle:

- ◊ Some manufacturer's specifications suggest that 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 the risk of an overturn increases. Drive slowly and turn smoothly.
- ◊ To prevent overturns, secure the load from shifting sideways.
- ◊ 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 you reach the slope. This will help reduce wear on the brakes.

- ◊ Reduce speed over rough terrain to prevent the utility vehicle from bouncing. Operator and riders have been thrown from utility vehicles.
- ◊ A second rider should occupy the passenger seat. Do not permit extra riders to ride in the cargo box. Use the handholds. Operators should wear the seat belt when the UTV has a rollbar.
- ◊ 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 your tractor, skid steer loader, and ATV knowledge to safely operate a UTV.

As with all machinery, use the device as it was designed. Utility vehicles are tools, not toys.

Utility vehicles can overturn at high speeds and while making sharp turns.

Figure 6.2.d. 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

Safety Activities

1. Use the Internet website **www.atvsafety.org** to solve crossword puzzles or to play word search games related to all-terrain vehicle safety.
2. Visit the John Deere website, **www.JohnDeere.com**, or the Bobcat website, **www.bobcat.com**, to learn about UTV specifications for weight, payload, and engine size.
3. Collect newspaper, magazine, or Internet news articles about ATV and utility vehicle injuries and deaths. Create a poster presentation to display at a local ATV or utility vehicle dealership.
4. What does the designation "100cc engine" represent? Using the math formula for volume of a cylinder (ask your teacher), calculate the diameter and height of the cylinder that would represent a 100cc engine cylinder. Use a sheet of paper to construct the cylinder. Answer the same question for a 500cc engine cylinder.

Telehandlers

Learning Goals

- Understand how a telehandler operation
- Understand the concepts of machine and load stability in operating a telehandler

Related Task Sheets

- 2.9: Hand Signals
- 3.1: Mechanical Hazards
- 4.1: Tractor Hazards
- 4.12: Tractor Stability
- 6.1: Skid Steers

Introduction

Large volumes of agricultural crops and inputs stored in large facilities have created the need for equipment that will lift and place the material at heights of 30 to 40 feet. Telehandlers are capable of lifting up to 10,000 pounds. It is important not to overload or operate on sloped ground.

Operators must be safe and prevent damage to the machine and facilities. Understanding the safe operation of the telehandler is the focus of this task sheet.

The telehandler requires as much understanding of stability as operating a tractor does.

Figure 6.3.a. Hay or straw bales can be stored in an area that requires the use of a telehandler. Credit: Michael Houtz, Penn State

Telehandler Components

Telehandlers are becoming more common on farms. These powerful units go by many names, such as material handlers. Technically, telehandlers are rough-terrain, variable-reach forklifts and are considered class 7 powered industrial trucks. However, they operate entirely differently from a forklift.

Boom

The telescopic (variable reach) boom can extend/retract to 30 to 40 feet and elevate to an angle of 70 degrees from the horizontal. Capacity may reach 10,000 pounds. Booms are marked in increments to alert the operator how far the boom is extended.

Frame Tilt

When operated on sloping ground the telehandler frame can be altered relative to the ground by 10 to 15 degrees in either direction to keep the boom vertical in position. A frame tilt/level indicator 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:

1. Front wheel steering where the front wheels turn, similar to automobiles.
2. Circle steering allows the front and rear wheels to react in opposite directions to permit a tight turning radius.
3. Crab steering 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) that can tilt farther forward and back than a forklift and can also 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 stationary.

Load Capacity

Telehandler load capacity depends on many variables. Lifting large loads to high storage areas may exceed the capacity of a machine. The operator must understand that each load and each position to which the load is lifted or moved has the opportunity to change the center of gravity and stability of the telehandler.

Figure 6.3.b. The telehandler load capacity chart must be used to determine if the weight of the round bales and the distance the boom must be extended to store them remains within the capacity range of the machine. Exceeding the weight and reach capacity of the telehandler could cause it to tip forward. Credit: Michael Houtz, Penn State

Figure 6.3.c. As the boom is extended a letter (circled) or number markings are revealed that are referenced in the operator's cab to give restrictions on how much weight can be lifted safely. A boom angle indicator is included. Credit: Jeff Mathison

Figure 6.3.d. A close-up of the boom angle indicator. Credit: Jeff Mathison

Figure 6.3.e. If the telehandler is equipped with outriggers use them to stabilize the machine during use. Credit: Jeff Mathison

Know how to interpret the load capacity charts found in the operator's cab.

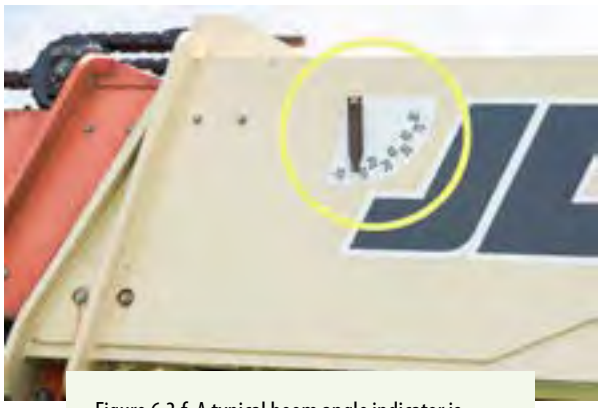

Figure 6.3.f. A typical boom angle indicator is visible to the operator from the cab seat. A similar indicator is found on the instrument panel to show frame angle. Credit: Jeff Mathison

Each of the following items, if handled incorrectly, can lead to a mishap:

- Boom angle and extension (see Figures 6.3.c, 6.3.d., and 6.3.f for boom markings and boom angle indicator)
- Load weight
- Use of outriggers, if equipped
- Rubber tires versus rigid tires
- Grade or slope
- Wind
- Lifting attachment

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 your training period on the telehandler, use this reminder on how to start the machine:

1. Complete a pre-inspection of the machine.
2. Sit in the operator's seat and fasten your safety belt.
3. Observe that all controls are in the neutral position.
4. Turn ignition switch to preheat position if equipped; start the engine when signaled.

5. Warm up the engine at half throttle.
6. Close the cab door.
7. Check 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, but test these on level ground.
- ◊ Lower the outriggers before lifting.
- ◊ Practice using the lift and leveling controls before moving a load.
- ◊ Check that other personnel and machines are not in the area.
- ◊ Plan your travel for best visibility.
- ◊ Keep the boom retracted and as close to the ground as possible.
- ◊ Start, stop, turn, and brake smoothly.
- ◊ Slow down for turns and uneven surfaces before reaching those hazards.
- ◊ 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.

Shutdown Procedure

When the work is completed, park in a safe location on level ground away from other equipment and traffic. Follow these steps:

1. Apply the park brake.
2. Shift transmission to neutral.
3. Retract boom and lower boom and attachments.
4. Let engine idle for three to five minutes to cool.
5. Shut off engine and remove key as directed by the employer/supervisor.
6. Unfasten your seat belt.
7. Use grab handles and exit the machine safely.
8. Block 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.

Figure 6.3.g. When finished with the 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: Jeff Mathison

Safety Activities

1. If you have never operated a telehandler, visit an equipment dealership and ask to sit in telehandler's cab to observe what controls are available and where they are located. This may be done with your employer's guidance as well.
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 and extending/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 two-wheel, four-wheel, and crab drive functions.
5. Practice picking up and lifting a load, extending the loaded boom, and lowering the load.

HOSTA Task Sheet 6.4

Using a Tractor Front-End Loader

Learning Goals

- Safely use a tractor-mounted front-end loader
- Understand how the center of gravity of a farm tractor changes as the front-end loader is used

Related Task Sheets:

- 4.2: Tractor Hazards
- 4.12: Tractor Stability
- 4.13: Using the Tractor Safely

Introduction

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 task sheet discusses safely using a front-end loader mounted on a farm tractor. (Similar task sheets dealing with skid steer and material handlers also discuss these safety ideas.)

Front-End Loader Components

Oftentimes 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 from which to attach the front-end loader.

Loader components include:

A. Tower columns, which are the back of the loader and attach to the tractor's mid-frame and may serve as the support legs. Some loaders will have support legs to support the front-end loader frame when it has been removed from the tractor if different from the tower columns.
B. Bar and saddle, found behind the bucket and that mounts the loader to the front of the tractor's frame
C. Lift arms and frame
D. Hydraulic system components (hoses and control valves)

Most manufacturers have designed quick attachment couplings to attach the front-end loader to the tractor. Use the operator's manual to identify the loader components before attempting to attach it to the tractor.

Check that all components are secure before operating the front-end loader.

Figure 6.4.a. Front-end loaders may be parked and have 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: Jeff Mathison

Center of gravity

Review Task Sheets 4.2: Tractor Hazards, 4.12: Tractor Stability, and 4.13: Using the Tractor Safely.

The tractor's center of gravity is engineered to maintain a stable "footprint" 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 (see Figure 6.4.b). With the center of gravity raised while operating on uneven surfaces or rough roadways, an overturn can occur more easily. Always travel with the bucket as low to the ground as possible. If working on a hill with a loaded bucket, travel uphill in forward and downhill in reverse.

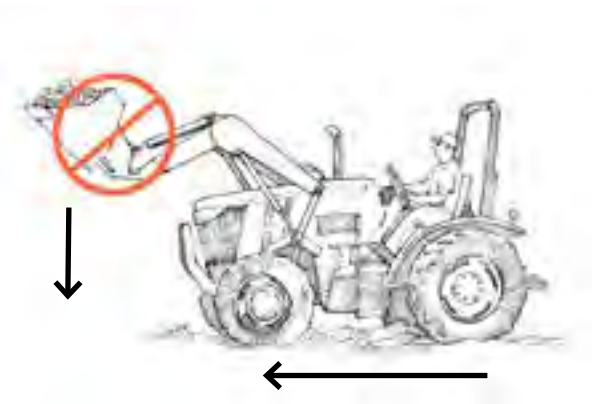

Figure 6.4.b. When operating the front-end loader, keep the loaded or empty bucket as low to the ground as possible while in transport. Sideways overturns can result if you try to travel with the bucket in the up position. Illustration by Jeff Mathison

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, when lifted with a front-end loader change the center of gravity of any tractor. The tractor can be more easily tipped as a result.

Loads can also roll back onto the operator. To reduce risk of overturn or load rollback:

- Use a wide front-end tractor for loader work rather than a narrow front-wheel tractor to improve stability.
- Understand that some loads are going to be too heavy for the tractor to lift. Know your machine's capacity.
- 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.
- Move slowly if loads must be carried high, and avoid jerky movements.
- Consider if the tractor needs more ballast (weight) added to the rear before you continue to use it. If the tractor feels like it is tipping during loading, reduce the load or add ballast to the rear end of the tractor.

◊ Make sure the load is not bigger in size than the bucket.
◊ Use several trips to complete the work rather than trying to move too much material in one load.

Heavy loads lifted high can tip the tractor. Materials can roll back off the bucket if too large.

Pinch and Crush Points

Front-end loader lift arms move closely to the tractor frame and mounting points. Other close-fitting parts include the connections between the bucket or attachments and the lift frame as these parts are rolled back during loading. These are places where a person can be pinched or crushed. To avoid pinching and crushing injuries:

◊ Be sure that bystanders or helpers move away from the front-end loader during use.
◊ Before making needed 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.

Figure 6.4.c. Extending the front-end loader with bucket or fork attachment moves bulky loads easily, but it 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: Jeff Mathison

Work Surroundings

Farm equipment operators must be aware of their surroundings as they go about the work to be done. Before operating the front-end loader, check the location of:

◊ fellow workers
◊ children and pets
◊ livestock and livestock equipment
◊ building corners and overhangs
◊ utility lines

Equipment operators can become so focused on their work they can overlook where other people or animals have moved in the work zone. Farms have children, bystanders, and pets that may not understand what you are doing or anticipate your movements. Be alert to these situations.

Buildings have been damaged by equipment operation. Be sure that you understand the width and height of the front-end loader and any cargo you are carrying in it. Avoid working too close to buildings if possible.

Most important, know the location of overhead power utility lines. Maintaining a safe distance from the utility lines. Contacting power lines with front-end loaders or the cargo can result in electrocution. To avoid electrocution, do not use the front-end loader bucket to dig into the ground unless you know where underground utilities are buried.

Keep the bucket low and drive slow.

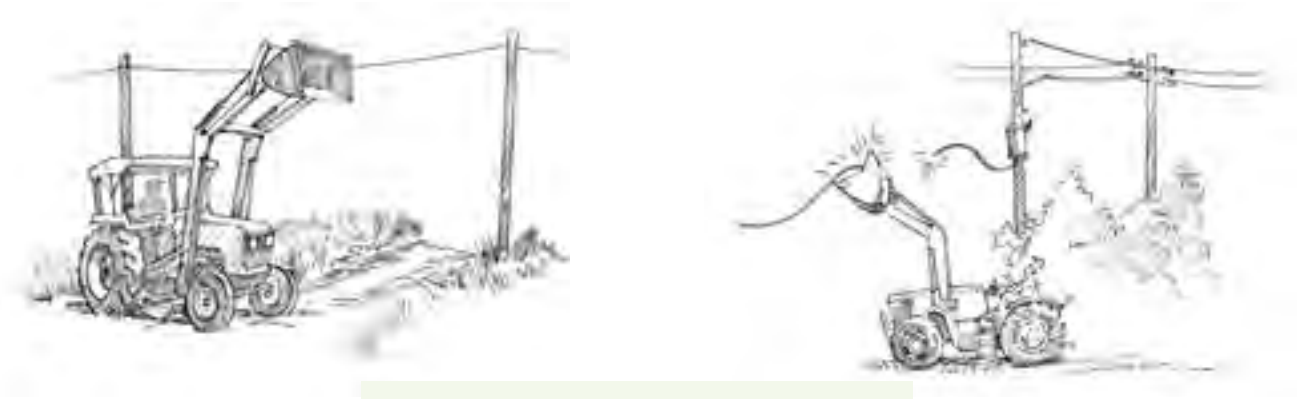

Figure 6.4.d. To prevent electrocution, lower the front-end loader bucket to avoid power lines crossing the work area. Illustrations by Jeff Mathison

Safety Activities

1. Answer these questions:
   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 where 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 not confused about what each control movement does as you use it. Request that a supervisor observe your initial efforts.
3. Using a pile of sand, sawdust, or mulch, practice scooping while observing how you approach the pile of material. Pay attention to how much you scoop into the bucket, and how heavy it is to lift. Slowly move the loaded material to another nearby location and dump it. Request that a supervisor observe your initial efforts.
4. When you have mastered safety activities 2 and 3 above, 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. Request that a supervisor observe your initial efforts.

Resources

Safety Management for Landscapers, Grounds-Care Businesses and Golf Courses. John Deere Publishing, 2001.

HOSTA Task Sheet 6.5

Dump Trucks and Trailers—Farm Use Only

Learning Goals

- Understand the concept of center of gravity of farm dump trucks and its potential to cause overturns
- Safely use farm dump trucks and trailers during on-farm use

Related Task Sheets

- 2.8: Hazard Warning Signs
- 3.1: Mechanical Hazards
- 3.6: Electrical Hazards
- 4.2: Tractor Hazards

Introduction

Farm owners have increasingly turned to the use of dump trucks and trailers to quickly and efficiently move the inputs and products off and around the farm. These inputs can be compost, gravel, fertilizer, or grain.

Serious property damage, crippling injury, and even death can result when these trucks overturn or the dump bed falls onto a worker during repairs or use.

This task sheet identifies risks associated with using dump trucks and trailers and how to avoid common hazards. This task sheet refers only to farm use of dump trucks and trailers and does not discuss road use of these vehicles.

Inexperienced or untrained operators should not be assigned to operate dump truck and trailers. Age restrictions in CDL licensing requirements may further remove younger employees from being considered for this duty.

Only properly licensed, experienced operators should be assigned to road use of farm dump trucks and trailers.

Types and Uses

Dump trucks and dump trailers are used for many farm chores, including hauling grain, silage, firewood, sawdust, wood chips, soil, gravel, sand, debris, and other pulverized or loose items.

Among the types of large trucks and trailers found on farms are semi-trailer end-dump trucks (Figure 6.5.a), pup trailers (Figure 6.5.b), and regular and long-bed straight dump trucks (Figure 6.5.c). Hereafter, these units will be referred to as farm dump trucks and trailers.

Farm dump trucks and trailers use hydraulic hoists to raise the bed during unloading. Raising the bed allows the contents of the load to slide out of the bed for unloading by gravity.

The remainder of this task sheet discusses the variable conditions, types of load and unloading surfaces, and mechanical issues that can create hazards when using farm dump trucks and trailers.

Figure 6.5.a. A truck with dump trailer. May be called a semi-trailer end-dump truck. Credit: Penn State Extension Ag Safety Team

Figure 6.5.b. A pup trailer. Credit: Penn State Extension Ag Safety Team

Figure 6.5.c. A regular dump truck. Credit: Penn State Extension Ag Safety Team

Dump Truck Hazards

Three situations present the most potential for a fatal injury involving on-farm use of large farm dump trucks and trailers.

One situation involves trucks and/or trailers tipping over while emptying loads. These rollovers happen for a variety of reasons and will be discussed in the "Instability Hazard" section.

The second situation occurs when a person works under a raised dump truck or trailer bed. Usually the person has not physically blocked the dump bed from coming down unexpectedly. The crushing injury from the dump bed or loaded bed is usually fatal.

The third scenario occurs when the dump truck or trailer bed comes into contact with overhead electrical lines and the driver or a helper located on the ground is electrocuted. This usually happens when the driver pulls away after emptying the load without lowering the bed.

In all three cases, a person can be crushed or electrocuted within seconds. There have been at least eight incidents in Pennsylvania involving farm dump trucks in the past few years. Since many incidents go unreported if a fatality is not involved, the number of incidents may be much higher.

Instability Hazard

A dump truck or trailer becomes less stable as its bed is raised, especially when the ground is not level or firm (Figure 6.5.e). The greater the length and height of the bed, and the greater the degree of slope, the greater the hazard for tipping over. As the bed is raised, it is important the load center of gravity stay between the frame rails of the bed, preferably right in the center. Even when the ground is relatively flat, a slight slope can be created by one set of tires settling into a hole or deep set of ruts, low tire pressure on one side, or a depression created on one side as an off-center load is unloaded

on soft ground. Driving or unloading too close to a ditch, road bank, or material pile edge can cause the rig to tip over as well. It is often a combination of these conditions that result in instability and a tip over.

Off-center and shifting loads often contribute to overturns. These can occur for a variety of reasons, including the load not distributed properly when loaded (e.g., top heavy or too much on one side) and material not flowing evenly out of the bed (e.g., wet or frozen material stuck to the sides or floor). Materials such as silage, high-moisture corn, and damp sand can hang up, causing uneven loads.

To reduce risk of overturns:

- ◊ Unload on a firm level surface.
- ◊ Keep the rig in a straight line, not jack-knifed.
- ◊ Avoid unloading in high winds.
- ◊ Consider a dump bed equipped with two hydraulic cylinders to reduce the chance of overturns.

Figure 6.5.d. A hydraulic lift cylinder raises the dump bed to unload materials. As the dump truck or trailer bed is raised, the center of gravity is also raised. When unloading, park the truck on a level, firm surface. Credit: Penn State Extension Ag Safety Team

Figure 6.5.e. Raising the dump bed on sloped ground increases the risk of rollover. Longer trailers, windy conditions, and uneven loads add to the risk. Never attempt to unload a rig that is parked in a jack-knifed position. Illustration by Penn State Extension Ag Safety Team

Dump trucks have a center of gravity just like that of a farm tractor.

Crushing Hazard

Workers have been crushed to death from dump beds unexpectedly coming down. Checking an unfamiliar noise or malfunction, performing routine maintenance (e.g., greasing), or making a repair may mean the operator enters the space between the dump bed and truck frame. In this work position, the risk of a crushing fatality can occur if the bed is lowered inadvertently by a worker or co-worker tripping a hydraulic control lever or by a mechanical or hydraulic component failure.

To reduce the risk of dump bed crushing injury or fatality:

1. Completely understand the dump bed controls and how the system works.
2. Use the manufacturer's locking device to secure the dump bed when working between the dump bed and truck frame (Figure 6.5.f).
3. If a problem exists for which you are not trained, immediately find a knowledgeable operator to help correct the malfunction.

Use the manufacturer's mechanical block device to prevent the bed from coming down during repairs and maintenance.

Figure 6.5.f. A wooden plank is **not** a suitable blocking device to secure a dump bed. Credit: Penn State Extension Ag Safety Team

Electrocution Hazard

Overhead power lines are a hazard. The possibility of electrocution exists with raised dump trucks or trailer beds contacting power lines. This may happen because of forgetfulness, haste, or impatience when the driver doesn't want to wait for the bed to completely lower before pulling away. If contact with power lines occurs, the driver is normally protected from electrocution because they are insulated from the electrical charge by the truck tires. If the driver leaves the cab and is in contact with the ground and the truck, they could be electrocuted. Some drivers, either from panic or lack of knowledge, attempt to leave the cab and are electrocuted. A person touching any part of the truck or trailer in contact with an overhead power line may also be electrocuted.

To avoid electrocution risks:

◊ Know the location of overhead power lines in relation to dump locations.

◊ Have a helper to observe for potential power line contact and to signal you for safe clearances.

◊ Always move the unit with the bed down.

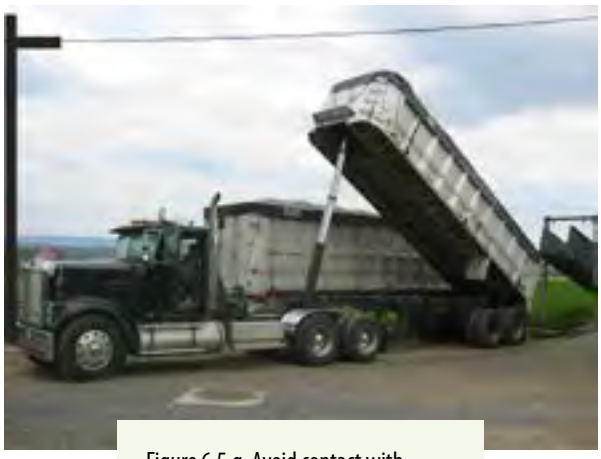

Figure 6.5.g. Avoid contact with overhead power lines. Credit: Penn State Extension Ag Safety Team

Safety Activities

1. Conduct a farm community survey to determine the extent of dump trucks, semi-trailer, end-dump truck, and pup trailer use in your community.
2. Conduct a survey of local farmers to find out how they received training in safe dump truck and trailer use.
3. Visit your local Driver Test Station to locate information on weight restrictions and CDL licensing requirements for off-farm or road use of the dump truck and trailer.

Reference

"Farm Dump Truck and Trailer Safety." Penn State Extension. **extension.psu.edu/farm-dump-truck-and-trailer-safety**.

Loading and Towing Equipment on a Trailer

Learning Goals

- ◊ Conduct a pre-use safety inspection
- ◊ Load and secure a load on a trailer
- ◊ Test electric trailer brakes before entering a public roadway

Related Task Sheets

- ◊ 4.12: Tractor Stability
- ◊ 4.14: Operating the Tractor on Public Roads

Introduction

Farm enterprises may have several fields or production locations that require transport of equipment in order to accomplish field work. A farmer may own or lease farmland several miles from the home farm. A new employee may be asked to tow equipment from one location to another.

Safe towing or transporting of equipment on trailers is the subject of this task sheet.

The operator of the towing vehicle is responsible for safe towing.

Towing Defined

The trailer must be safe to take on the road. This means that the load or cargo on the trailer cannot weigh more than the trailer is designed to transport. The combined weight of the trailer and the load on it be should not be more than the towing vehicle is designed to haul. The hitch on the towing vehicle must be of the correct size and have safety chains, locking clips, and lights. Larger trailers are often equipped with brakes. These items must be in good condition and used properly. Inspecting and testing equipment before you get on the road is important. All of these items are discussed in the following sections. The operator also must use safe driving habits while towing a load.

Figure 6.6.a. This heavy-duty trailer can safely handle hauling this tractor. The towing vehicle must have a hitch rated for the load, be able to pull the load, and have sufficient braking capacity to stop the load. Credit: Penn State Extension Ag Safety Team

Pre-Use Inspection

Pre-inspection should be done in three phases:

1. Walk around the trailer to inspect tires and look for damage to light fixtures, missing tail gate pins, or other loose or damaged parts.
2. After hitching the trailer to the towing vehicle, turn on the vehicle lights and be sure that trailer marking lights, turn signals, brake lights, and emergency flashers are functional. Replace any lamps or fuses that are burned out before taking the trailer onto the highway.
3. Inspect tie-down straps or chains and chain binders. Frayed tie-down straps or deeply nicked chains have reduced strength and may not be strong enough to secure the load. Replace damaged straps or chains immediately.

GVW and GCVW

The towing vehicle must be capable of pulling and stopping the trailer and its load. Steering and braking are greatly affected when cargo weight is heavier than the towing vehicle can handle.

Manufacturers have established a Gross Combined Vehicle Weight (GCVW) rating for the tow vehicle's weight plus the loaded trailer weight. This GCVW is found in the vehicle's serial number or in the operator's manual for that vehicle. Remember, this weight includes fuel, passengers, and the cargo. Trying to pull too heavy of a load can end in disaster.

Hitch Point

Not all receiver and ball hitches are the same. Ball diameter is just one factor. The hitch, receiver/ball mount, and ball must be heavy enough for the load to be towed. Each component has a rating tag or load rate stamped in the metal. The lowest rating of the three parts is the safest load that can be pulled.

Regulation Safety Chains

Safety chains are required while towing a load. These chains provide some security should the hitch be damaged or come loose. Fasten chains in a criss cross manner to form a cradle beneath the tongue should the hitch fail. The operator can slow the load and move from the highway until repairs can be made. Older safety chains have an open end, but new regulations require a closed-chain hook.

Figure 6.6.b. Safety chains must be equipped with a safety clip and should be rated at or above the GVWR, or the total weight of loaded vehicle and loaded trailer. Too short of a chain can reduce turning radius; too long of a chain can drag on the roadway. To shorten long chains, twist them around each other to a desired length. Credit: Penn State Extension Ag Safety Team

Testing Electric Trailer Brakes

Before entering the roadway with a loaded trailer, it is advisable to check the electric tow brakes on the trailer. If you do not know how to use trailer brakes, ask for a demonstration from your employer. Be sure to check the operator's manual for your specific brake setup.

To test the electric brakes:

- Locate the controller/adjuster (found beneath the instrument panel of the towing vehicle). There is an adjustment button (+/-) and a sliding lever to check the braking power of the trailer. Heavier loads will be adjusted to the + direction; lighter loads may need less braking.
- On a level surface, begin to move forward slowly with the load and then:
    1. Shift the tow vehicle transmission to neutral; next, use the slide lever on the brake controller to bring the load to a stop using the trailer brakes.
    2. The trailer should stop the load. If the trailer brakes jerk the truck to a stop, you have too great a trailer brake adjustment. Adjust the trailer brakes until the load stops smoothly. If the trailer cannot stop the load, adjust the controller to a higher number and repeat the test.

Some trailers may have no brakes or may be equipped with surge brakes. (See Figure 6.6.c for an explanation of surge brakes.)

Trailers may have no brakes, surge brakes, or electric brakes.

Figure 6.6.c. Surge brakes assist in braking capacity and are activated when the tow vehicle slows down. The trailer pushes against the mechanism in the trailer hitch, causing pressure on the trailer brakes. There is a cable coming out of the hitch that is connected to the tow point and a break away switch in the trailer hitch. Be sure the cable for these brakes is connected to the bumper of the tow vehicle. Credit: Penn State Extension Ag Safety Team

Safe Loading/ Unloading

Follow these steps to load equipment on the trailer:

- Place the trailer hitched to tow vehicle on a firm, level surface.
- Use outriggers and chock blocks (see Figure 6.6.d).
- When loading equipment such as a skid steer or two-wheel-drive tractor, remember that 60 percent of the weight is at the rear end and 40 percent is at the front; therefore, back the heavy end of the equipment onto the trailer first (see Figure 6.6.d).
- Drive or load the equipment onto the trailer, keeping the load balanced. The heaviest part of the load should be centered over the axle(s). Placing the load too far forward places too much weight on the tongue of the trailer, while too far back lifts the trailer tongue and reduces traction of the tow vehicle.

Note: Unbalanced weight distribution of equipment can cause the load to tip during loading due to the slope of the loading ramp and the machine's center of gravity.

Figure 6.6.d. Where possible, back the equipment onto the trailer. The heaviest section should be parked over the dual axles. This trailer has an outrigger attached to the end-gate, which keeps the trailer level. Note also that chock blocks are used to keep the trailer from rolling. Be sure the trailer is hitched to the tow vehicle before attempting to load the trailer. Failure to use the outrigger jacks during loading may place undue stress on the vehicle and trailer hitch. Credit: Penn State Extension Ag Safety Team

Figure 6.6.e. This skid steer minus an attachment is rear-end heavy. Attempting to load it on the trailer in this direction moves the center of gravity to the rear and causes the skid steer to tilt to the back. Credit: Penn State Extension Ag Safety Team

Securing the Load

Secure the equipment with tie-down straps or chains and chain binders. Check the tie-down straps for wear. Do not use them if they are worn or frayed. Chains and chain hooks should be inspected for deep nicks and/or weak links. Use a chain rated for the load (a 5/16-inch chain is rated for 4,700 pounds of strength, a 3/8-inch chain is rated for 6,600 pounds of strength, and a ½-inch chain is rated for 11,300 pounds of strength).

Secure the front and rear of the machine by tying the straps or chains downward and outward. This prevents the machine from shifting forward or rearward during transport.

85–90% of the load weight should be carried over the axles; only 10–15% of the weight carried on the tongue.

Safety note: Towing/trailering of engine-driven equipment equipped with a turbocharger may require blocking of the airflow into the turbocharger through the exhaust. While it is rare, expensive turbochargers have been damaged by transporting tractors with the exhaust pipe facing the direction of travel. Damage occurs when an exhaust valve in the open position allows air to flow through the turbocharger, freely rotating the turbocharger blades. Since the turbocharger is not being operated by engine power, turbocharger bearings can burn due to no lubrication being pumped to those turning parts.

Figure 6.6.f. Secure the load (front and back) with straps or chains pointing down and outward. Credits: Penn State Extension Ag Safety Team and Michael Houtz, Penn State

Safety Activities

1. Ask a trained individual to demonstrate how to drive a tractor or skid steer onto a trailer for you. Then perform this task under their supervision. Observe the position of the load as it is placed over the axle(s) of the trailer. Remember that 85 to 90 percent of the weight must be over the axle(s).
2. Ask the same individual in Activity 1 to demonstrate the correct way to secure a load on a trailer using tie-down straps or chain and chain binders. Repeat this task with their supervision.
3. What is the GVW of the tow vehicle you will use? What is the GVW of the trailer you will be using? Add the two GVW weights together for the GCVW. Check the GCVW weight you have calculated and compare with the information found on the tow vehicle serial number plate (usually found inside the door frame). Is the total weight within the limits shown on the serial number plate?
4. Federal regulations include Commercial Driver's License (CDL) requirements for trucks and trailers over a certain CGVW. Some exemptions may apply to agriculture. Use an Internet search engine to find if your state has other requirements or exemptions.
5. What is the weight of the load you are about to tow? If only 10 to 15 percent of that weight can be on the tongue of the trailer, how much weight can be on the tongue? If a heavy enough set of wheel-type scales (scale beneath each wheel) are available, load the equipment on the trailer, chock the wheels, place one scale beneath the jack, disconnect from the tow vehicle, and raise the tongue until the loaded trailer is setting on the scales. What is the weight you have on the tongue of the trailer?

Resources

"Keeping the Trailer Connected to the Truck: Understanding the Hitch System." Purdue Extension. **www.extension.purdue.edu/extmedia/ppp/ppp-92.pdf**.

Safety Management for Landscapers, Grounds-Care Businesses, and Golf Courses. John Deere Publishing, 2001.

Augers and Elevators

Learning Goals

- Learn how an auger and elevator operates
- Identify auger and elevator hazards and how to avoid entanglement and electrocution

Related Task Sheets

- 2.3: Reaction Time
- 3.1: Mechanical Hazards
- 3.6: Electrical Hazards
- 3.10: Grain Bins

Introduction

Due to the volume of grain produced, augers and elevators are necessary to quickly and efficiently move grain. These machines are used to process 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 exist that have never been guarded. The risk of being pulled into and entangled in the moving parts of unguarded machines is high.

This task sheet provides facts that may help you avoid an injury or fatality due to auger and elevator hazards. Review Task Sheet 3.1: Mechanical Hazards.

How an Auger Works

The auger is a shaft with metal or hard plastic, screw-thread fluting attached. The end of the auger can be placed into a grain pile, bin, or wagon and begin to move material very quickly. The turning part (auger) and the auger tube move close enough together to be able to snag loose clothing, feet, or hands. Entanglement, amputation, or both can occur. Elevator belts and pulleys or chains and sprockets can entangle the operator if guards are not in place.

Figure 6.7.a. 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 user into the machine. Augers should be guarded as shown. Auger guards must be kept in safe condition. The picture shows how effective the guard can be at protecting the user. Credit: Penn State Extension Ag Safety Team

Safely Guarding Augers

Engineering standards by the American Society of Agricultural and Biological Engineers (ASABE) call for exposed auger flights to be guarded as follows:

- ◊ 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.

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.

Auger guards can become damaged after years of use. Damaged auger guards increase the risk that an injury or fatality can occur. Report damaged or missing auger guards to the employer or supervisor.

Figure 6.7.b. Missing auger guards and shields increase the risk for injury or fatality. Your employer must provide a safe workplace. Credit: Agricultural Youth Work Guidelines

Augers must be guarded. Report missing guards and shields to your employer.

Elevators

Elevators carry hay and straw bales or other agricultural materials 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 PTO.

Commercial elevators may be purchased without a power source, which the end-user 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.

Figure 6.7.c. An example of an elevator for moving hay. 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 for images: Jeff Mathison

Elevators are not ladders or people movers.

Figure 6.7.d. A total mix ration (TMR) mixing wagon loads from the top by high-lift bucket. This is not a normal work position and because the distance away from the operator is considered to be guarded by location. (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 mixer wagon form a "barrier" to prevent the hazardous area from being reached inadvertently.) DO NOT ENTER this mixing space that has three augers moving close together. Credit: Michael Houtz, Penn State

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.

Don't forget that when the job is done and the auger or elevator is to be moved to a different site, the auger tube may still have grain or feed in it, and the elevator can be top heavy. Be sure to empty the auger tube before transporting the auger to prevent up-ending. Lower the elevator or auger to reduce the center of gravity and prevent tipping forward or sideways.

Augers and elevators must be lowered to transport position to avoid contact with power lines around the farmstead. Electrocution can result if contact is made with the wires.

Figure 6.7.e. There is an increased risk of contacting overhead power lines when the auger or elevator is not lowered for transport. Illustration by Jeff Mathison

Safety Practices for Augers and Elevators

1. Read and understand the operator's manual before using the auger or elevator.
2. Have the owner show you how to use the auger or elevator and then observe you successfully doing the job for which you are assigned.
3. Keep all safety shields and devices in place.
4. Make sure the area is clear of bystanders before operating the auger or elevator.
5. Keep hands, feet, and clothing away from moving parts.
6. Shut off power to adjust, service, or clean the auger or elevator.
7. To prevent a fire, keep crop debris and dust from accumulating around a motor or engine. Dust can catch fire or even explode.
8. Do not ride an elevator to the top of the barn or bin as a personnel transport. Falls and entanglement can occur.
9. Consider that a small internal combustion engine used as the power source can be a source of heat or sparks that may ignite hay, straw, or grain dust that accumulates around the engine.
10. Keep a 10-pound ABC fire extinguisher available for emergency use.

Keep a 10-pound ABC fire extinguisher available for emergency use.

Safety Activities

1. Search the Internet for agricultural injuries and/or fatalities involving an auger or elevator. Analyze three of these incidents to see if the incidents had anything in common. Compare the age of victim, machine condition, time of year, and any other factor in your analysis. A good source of information is **extension.psu.edu/business-and-operations/farm-safety**. Look for the annual farm fatality reports on this website hosted by the Penn State Extension Agricultural Safety and Health Program.
2. Conduct a safety check on the augers and elevators on your farm, a relative's farm, or a neighbor's farm (with their permission and supervision if possible). Using the ASABE standards and safety recommendations provided above, develop a report with pictures that could be given to the owner or presented to your agriculture class or 4-H club members.
3. Solve this 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 or proportion-type calculation.

References

American Society of Agricultural and Biological Engineers (ASABE), ASAE S361.3, Safety for Portable Agricultural Auger Conveying Equipment (Revised 2005).

American Society of Agricultural and Biological Engineers (ASABE), ANSI/ASAE S493.1, Guarding for Agricultural Equipment (Revised 2008).

Farm and Ranch Safety Management. John Deere Publishing, 2009.

Silage Defacers

Learning Goals

- Understand silage removal procedures
- Safely use silage defacing equipment

Related Task Sheets

- 3.1: Mechanical Hazards
- 3.9: Silos
- 3.9.1: Horizontal Silo Safety
- 3.9.1.1: Packing Forage in a Horizontal Silo

Introduction

Expanding livestock feeding operations require the handling of larger quantities of forage and silage. Many operations such as dairy farms will store silage horizontally in trenches, bunkers, or drive-over piles. Trenches, bunkers, and piles can contain thousands of tons of silage often packed to depths of 20 feet or more.

Due to the size and height of silage being stored, farmers need equipment to safely remove it for feeding. This task sheet addresses the safe use of silage defacers.

The Work of a Silage Defacer

Silage defacers have been designed to loosen silage from tightly compacted trenches, bunkers, and piles. Hydraulic-powered versions and toothed, nonrotating defacers are available. When placed on an extendable boom, the defacer 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 removal of enough silage to stay ahead of spoilage without excessive disruption of the tight pack of the silage.
- It is important to prevent silage pile collapse from continuous undercutting of the bottom of the silage feed-out face.

Figure 6.8.a. A hydraulic-powered, revolving-type silage defacer mounted to a material handler or 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: Jeff 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.

Figure 6.8.b. 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: Jeff Mathison

Safety Activities

1. Search YouTube for silage defacer equipment. Watch the videos to see how the equipment is operated. After watching the videos, make a list of the hazards that you can identify.
2. After listing the hazards involved in using a silage defacer, develop drawings of safety symbols that could help a person understand these hazards.
3. Conduct a class or club discussion to identify how many farms or ranches in your community have horizontal silage trenches, bunkers, or drive-over piles and how many tons of silage are estimated to be in storage.

Resources

"Horizontal Silo Safety." Penn State Extension. **extension.psu.edu/horizontal-silo-safety**.

Silage Bagging and Bale Wrapping Equipment

Learning Goal

◊ Safely use forage bagging and bale wrapping equipment

Related Task Sheets

◊ 2.9: Hand Signals
◊ 3.1: Mechanical Hazards
◊ 3.2: Noise Hazards and Hearing Protection
◊ 6.4: Using a Front-End Loader

Introduction

Developments in silage storage methods have given rise to the use of large plastic bags or wrapping. Crop harvest efficiency and lowering the costs of storage have been the driving forces behind the use of this equipment. These machines are designed to store large quantities of forage rapidly. Since 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.

This task sheet discusses the safe operation of silage bagging and bale wrapping equipment.

The Silage Bagger

Silo bags are filled using a machine that functions like a sled with a large plastic bag attached to one end. The silage bagger is driven from the PTO of the bagging tractor, which has been left in neutral and is therefore gradually pushed forward as the silage bag is filled. Bags are filled in a straight line as the tractor's steering is held straight. The bagging tractor's PTO is in operation for the entire fill period (see Figure 6.9.a). Operators and bystanders are at risk in the area close to the turning PTO.

The plastic silage bag is loaded in a similar manner to any other silo, but in this case the forage wagon being unloaded is moved progressively forward with the bag loader as the plastic bag is fed from the bagging machine. A tablelike 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. Once filled, this pressure is released and the rear gate mechanism falls to the ground. Bystanders must be kept away from the filling operation.

Figure 6.9.a. 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. Credit: Jeff Mathison

Figure 6.9.b. From the rear of the bagging equipment, the end-gate and cable braking system are shown. Large industrial disc brake(s) and a simple brake hand pump and brake pressure gauge control the rate of cable release. Silage bags may have convenient "stretch gauges" marked continuously 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 end-gate when the "bag" is filled. The end-gate can drop heavily to the ground. The close quarters between 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: Penn State Extension Ag Safety Team

Safe Practices Around Forage Bagging Equipment

While silage bagging operations have reduced the potential of falls from an upright silo, other safety hazards exist when using silage bagging equipment. For example, 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 there spinning its tires with him trapped beneath.

Unloading equipment is powered by tractors that are stationed next to each other. Limited access to this area should be expected. 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 Task Sheet 3.1: Mechanical Hazards.

Heed these points:

- ◊ Ask your supervisor to demonstrate how the machine is operated and what can go wrong.
- ◊ Remember to avoid loose or torn clothing, which can easily become entangled.
- ◊ Keep shields in place.
- ◊ Do not step over turning PTO shafts.
- ◊ Stop the machine to unplug any jamming that may have occurred from too rapidly feeding the unloading table or from plastic wrap that may have 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 that silo gases can accumulate near bag openings if the fill process will occur over several days.

◊ Remember, when unloading silage from the bag, the front-end loader must be carried low to the ground to prevent tractor rollover.

Figure 6.9.c. Handling silage or bales for wrapping may require a telehandler or tractor front-end loader. Be sure to follow safety practices. Travel with the load as low to the ground as possible. A heavy bucket of silage or bale will raise the machine's center of gravity as it is lifted. This will increase the risk of a tractor rollover. Credit: Michael Houtz, Penn State

Consider the space between the wagon or truck being unloaded and the bag being filled to be a "hazard zone."

The Bale Wrapper

Round hay bales may be wrapped in the baling machine itself, but typically bales are dropped in the field and wrapped later. The bale wrapper shown in Figure 6.9.d utilizes 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 and the bale dropped from the support table, and the process is repeated. Dozens of bales can be wrapped per hour.

The operator of the bale wrapper is physically removed from close proximity to the machine's turning parts, but hazards still exist.

Figure 6.9.d. 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 lifted into place for wrapping. Since 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: Penn State Extension Ag Safety Team

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 still exist and injuries occur while using a bale wrapper.

Hydraulic power removes many turning parts, but it may expose the operator to hydraulic-related hazards. In addition to hot hydraulic fluid, hoses can develop pinhole-size leaks under pressure. Handling or inspecting hoses for leaks can be done with a piece of cardboard, a mirror, or a small piece of glass. Never use your fingers or hands to check for hydraulic leaks. Hydraulic oil injected into the body must be treated immediately as a medical emergency.

The lift arm device and support table are moving parts that pose pinch point or shear point hazards. Understand that these areas can cause injury or fatality.

Round bales are heavy and can roll. Once wrapped, they are dropped to the ground by machine power and gravity. Crushing incidents are possible.

It is important to keep children and bystanders away from the bale wrapper during its operation.

When moving wrapped hay bales, remember that rollovers can occur when heavy loads change the center of gravity of the tractor or skid steer being used to move the bale.

As with all machinery, be aware of the surroundings. Bystanders are at risk.

Safety Activities

1. Attend an agricultural exposition in your state and watch a field demonstration of how the bale wrapping equipment operates.
2. Measure the length and diameter of a silage bag. Calculate the volume of this "tube" in cubic feet. If a cubic foot of corn silage would weigh 35 pounds, how many tons of silage are being stored?
   Use this formula:
   volume = $3.14 \times \text{radius}^2 \times \text{length}$
   Remember to use radius, not diameter, follow the order of operations in math, and that there are 2,000 pounds in a ton.
3. Calculate the cost per bale to wrap hay. You will need to find out the cost of a roll of plastic film and how much is used per bale and then calculate the cost per bale.
4. Research how agricultural plastic is recycled. Can it be recycled? What are some of the problems with recycling agricultural plastics? Make this a current event presentation to your class or group.
5. Use the Internet to locate equipment that is used to move and feed out plastic wrapped hay bales. What kinds of equipment are available?

General Class Information

Contact Info	Instructor 1	Instructor 2	Instructor 3
Name			
Address			
Phone			
Email			

Schedule

Location

Date	Day	Time	Topics	Task Sheets

Written Test:

Date: _____ Location: _____

Operating Skills and Pre-op/Driving Test:

Date: _____ Location: _____

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