Lesson A7–9

Operating, Calibrating, and Maintaining Animal Waste Management Systems

Unit A. Mechanical Systems and Technology

Problem Area 7. Agricultural Equipment Systems

Lesson 9. Operating, Calibrating, and Maintaining Animal Waste Management Systems

New Mexico Content Standard:

Pathway Strand: Natural Resources and Environmental Systems

Standard: VI: Identify public policies and regulations impacting environmental services to determine their effect on facility operation.

Benchmark: VI-A: Consult reliable resources or training to identify the major laws impacting environmental services.

Performance Standard: 2. Describe job-related activities subject to the Occupational Safety and Health Administration (OSHA).

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Describe the principles of waste management systems.
2. Identify animal waste characteristics.
3. Explain operating practices used in animal waste management.
4. Describe the calibration of waste management systems.
5. Explain the maintenance procedures for waste management systems.

List of Resources. The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany the lesson:

Bartok, John W., Jr. *Fertilizer and Manure Application Equipment* (NRAES-57). Ithaca, New York: Northeast Regional Agricultural Engineering Service, 1994.

Dougherty, Mark, et al. *Liquid Manure Application Systems Design Manual* (NRAES-89). Ithaca, New York: Northeast Regional Agricultural Engineering Service, 1998.

Livestock Waste Facilities Handbook (MWPS-18). Ames, Iowa: Midwest Plan Service, Iowa State University, 1998.

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters
Copies of student lab sheets
Examples of manure handling equipment

Terms. The following terms are presented in this lesson (shown in bold italics):

Anaerobic
Earth basins
Pits
Semi-solid manure

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Display a quart jar of manure to students. Ask them what it is and what it can be used for. Lead a discussion concerning the importance of waste management systems.

Summary of Content and Teaching Strategies

Objective 1: Describe the principles of waste management systems.

Anticipated Problem: What are the principles of waste management systems?

I. Several items should be considered when operating a waste management system. Base system selection on economic, engineering, public reaction and regulation, and numerous factors related to agriculture and the operation.

   A. The following are animal waste management principles.

      1. All waste management systems start with the source of wastes: an animal, the milkhouse, or lot run-off.
      2. Ultimately, all systems end in the soil; no pollutant is intentionally released to a stream, subsurface tile, or drain.
      3. All systems are compromises between investment, labor, convenience, aesthetics, and regulations.
      4. No system is best. Each component, facility, or process has advantages and disadvantages. The system used depends on personal preference, available capital and labor, waste sources, soil type, cropping practices, and a number of other factors.

   B. Considerations regarding the type of waste system used include:

      1. Looking objectively at where the operation is, where it is desired to be, and some likely ways to get there.
      2. Identifying waste sources. A large source may suggest large equipment and some automation. A small source may suggest staying with low investment and a little more labor. One enterprise may have several sources: free-stall barn, milking parlor, milkhouse, outdoor lot, etc.
      3. Considering all alternatives if a change is being made in the operation such as, expanding, remodeling, rebuilding, etc.
      4. Considering major management options such as different kinds of housing, various types of waste handling equipment, and disposal alternatives.

   C. Federal, state, and local regulations attempt to minimize or eliminate pollution.

      1. A well-designed system can achieve these goals and also have advantages for the livestock operation.
      2. Federal regulations apply to all states and to operations over a certain size or those that discharge wastes into surface or ground water.
      3. State and local governments may impose additional or more stringent requirements, such as facilities with specific runoff holding capacities, specific land application times, and procedures for ground water protection.
      4. Other regulations, such as zoning laws and public health laws can affect a livestock facility's design, construction, and operation, and its manure management program.

Use TM: A7–9A to highlight manure and waste factors. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 1 in Livestock Waste Facilities Handbook is recommended.

Objective 2: Identify animal waste characteristics.

Anticipated Problem: What are the characteristics of animal waste?

II. Animal waste characteristics vary depending on the species of livestock. The quantity and composition of wastes produced influence livestock waste facility design.

   A. The properties of manure depend on several factors: animal species; ration digestibility, protein and fiber content; and animal age, environment and productivity. The waste system must also be able to handle added bedding, soil, water, hair, etc.

   B. Waste with 20 to 25 percent solids content (75 to 80% moisture content) can usually be handled as a solid. It can be stacked and picked up with a fork loader. Liquids need to be drained and the waste dried or bedding added to get solid waste.

   C. In the 10 to 20 percent solids content range, handling characteristics vary depending on the type of solids present.

   D. Waste with 4 to 10 percent solids content can usually be handled as a liquid, but may need special pumps.

   E. Waste with 0 to 4 percent solids content is handled as liquid with irrigation or flushing consistency. Liquids which have had the larger solids settled or filtered out, or wastes with dilution water added may have 4% or less solids.

   F. Consider the air quality in the vicinity of the operation as well as inside the livestock buildings. Wastes stored under slotted floors may be in buildings long enough for bacterial action to produce gases and strong odors.

      1. Odor can be a nuisance to producers and cause complaints or lawsuits by neighbors.
      2. Noxious gases can irritate both livestock and the operator, and can be harmful and even lethal.

Use TM: A7–9B as visual material to emphasize the nutrients in livestock waste. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 2 in Livestock Waste Facilities Handbook is recommended.

Objective 3: Explain operating practices used in animal waste management.

Anticipated Problem:

III. Operating practices used in animal waste management can be divided into collection, transporting, handling, storing and applying.

   A. When selecting a collection system, consider the type of facility, labor requirements, investment, and total waste handling system.

1. Solid and semi-solid manure can be collected with tractor scrapers, front-end loaders, or mechanical scrapers.
2. Liquid manure can be collected with scrapers, flushing systems, gravity flow gutters or slotted floors.
3. Building floors can be slotted or solid.
   a. Slotted flooring rapidly separates from the location of animals. Slotted flooring materials, spacing, and width depend on the manure properties and experience with slipping, foot injury, and other animal response. When selecting slotted flooring , consider initial cost, predicted life, intensity of use, strength, corrosion, noise, and replacement cost.
   b. Sloped solid floors aid manure movement toward gutters or slotted areas. Animal traffic tends to work manure down slopes of about 4 percent or more. Slopes over 8½ percent can cause footing problems.
4. Several collection methods are possible. Scrapers remove manure regularly, so building and livestock cleanliness is easier to maintain.
   a. Shallow manual gutters involve manure being hand scraped from the gutter directly outside or into a sump or deep narrow collection gutter. The gutters are scraped every day to control odors.
   b. Mechanical scrapers can reduce manual labor requirements depending on the storage method and the degree of cleanliness desired.
   c. In a flush system, a large volume of water flows down a sloped, shallow gutter or alley. Water may be recycled from a lagoon, earth basin, or holding pond for flushing. How often the gutter is drained depends on the rate at which liquids accumulate. This rate is influenced by the amount of waste water.

B. Transporting wastes from an animal facility to storage may involve a large piston pump, pneumatic pump, centrifugal pump, or gravity. The system selected depends on the individual farm's waste characteristics, housing system, bedding practices, labor availability, and waste storage system.

C. Manure can be handled as a solid, semi-solid, or liquid. The amount of bedding or dilution water influences the form. The form influences the selection of collection and spreading equipment and the choice of storage type.

D. Storage design varies by state because of climate and pollution control regulations. Local regulations should be checked before planning manure storage.
1. The site where manure is stored is important. Considerations in site selection include:
   a. Evaluating the site and soil conditions carefully to avoid contaminating ground and surface waters.
   b. Avoid locating unlined storage over shallow creviced bedrock or below the water table.
   c. Avoid storing manure in sandy or gravelly soils or other areas where serious leakage can cause groundwater contamination.

d. Consider soil characteristics to a depth of at least 3' below the proposed storage bottom.
e. Checking for buried utilities and drainage tiles.
f. Considering all farmstead operations, building locations, and prevailing winds.
g. Allowing at least 100' between a water supply and the nearest part of a storage. Dairy operations need to check with milk and health authorities for minimum spacing requirements between manure storage and milking facilities.
h. Locating, sizing, and constructing storage facilities for convenient filling and emptying and to keep out surface runoff. Provide all-weather access.
i. Providing enough storage capacity to spread manure only when field conditions, labor availability, weather, and local regulations permit.

2. Liquid manure can be stored in pits, earth storage basins, above ground tanks or anaerobic lagoons.
    a. ***Pits*** have vertical sidewalls, are lined and are below grade. They may be either in buildings under slats or solid floors; or outside and usually separated from the building. Below-ground storage can be used for semi-solid and liquid manure. Manure with up to about 15 percent solids can be agitated and pumped. Storage depth may be limited by soil mantle depth over bedrock, water table elevation, and possibly, effective pump lift.
    b. ***Earth basins*** are earth-walled structures formed by excavation and earth berms. They are generally partly above and partly below grade. They may or may not be lined. The advantages of earth basis are:
        i. They provide long-term storage at low to moderate investment.
        ii. They are designed and constructed to prevent ground and surface water contamination.
        iii. They eliminate the problem of hazardous gas entrapment and reduce the potential for fatalities.
    c. Above-ground manure tanks are circular silo types or rectangular structures.
        i. They are more expensive than earth basins and are usually not used to store runoff or dilute wastes.
        ii. They offer a good alternative where basins cannot be used due to site limitations or aesthetics.
        iii. They work well for enclosed buildings, but they are difficult to use for open lots because of the variation in manure consistency.
    d. An anaerobic lagoon is a biological treatment system that is designed and operated for biodegradation. Biodegradation converts organic matter (feed, bedding, body byproducts) in animal wastes to more stable end products.
        i. ***Anaerobic*** process occurs without free oxygen. It liquefies or degrades high oxygen wastes. They can decompose more organic matter per unit volume that aerobic processes.
        ii. Well designed lagoons give off a musty odor.

iii. Anaerobic lagoons handle high loading rates but give off some septic odors.

iv. Anaerobic lagoons liquify and breakdown manure solids, but not all wastes added are completely degradable. Sludge accumulation depends on management, environment, waste characteristic, and loading rate.

3. ***Semi-solid manure*** is manure with excess liquids drained off and some bedding added to increase solids content.

   a. Semi-solid manure storage allows waste from many sources to be stored in one facility and handled with the same equipment.

   b. They can be an outside facility with picket dams to drain off rainwater or roofed structures.

   c. The hauling schedule from a semi-solid storage facility is flexible.

   d. If rainwater is drained from uncovered storage, manure with semi-solid characteristics can be handled with loaders and endgate or flail-type spreaders.

      i. Drained storage allows a producer to deposit semi-solid manure in an uncovered storage and maintain semi-solid handling characteristics by draining off rain water.

      ii. A picket dam removes only rainwater that falls on the storage; it does not reduce the water content of the manure.

4. Solid manure storage is used where manure dries sufficiently or where enough bedding is added to make it a stackable solid.

   a. Picket dams should be installed to drain rainwater, if located outside.

   b. Provide for convenient filling and unloading with a tractor mounted loader or scraper, elevator stacker, or piston pump.

E. The method of applying waste is determined by the form of the waste. Wastes with 20 percent or more solids can usually be handled as a solid.

1. Solid waste characteristics vary with the animal, ration, amount and type of bedding, time of year, and the amount of liquids separated from the solids. Manure collected in a settling basin can contain soil and debris. Solid waste spreaders are box-type, flail-type, dump trucks, earth movers or wagons. A spreader should distribute wastes uniformly. Spreader boxes are steel or wood and need to be watertight for road transport. Spreader mechanisms include paddles, flail, and augers. The feed apron, which moves the waste to the spreader, is often variable speed. The spreading mechanisms can be either ground or PTO driven. Flail-type spreaders are tanks with open tops and usually have a shaft mounted near the open top and parallel to the main axis of the tank. Chain flails on the shaft throw the wastes out the side of the spreader as the shaft turns. Large spreader capacity reduces the number of trips to the field but can increase soil compaction.

2. Liquids are spread on fields with tank wagons, applied with irrigation equipment or digested in a lagoon before field spreading. Wastes with up to about 4 percent solids can be handled as a liquid.

a. If large quantities are handled, a pipeline may be preferred over tank wagons to reduce the number of trips.

b. Settle out solids if possible or prevent large solids from passing though the pump.

c. Required pump capacity is influenced by the amount of wastes; time, labor and available power source; land, and equipment costs. For cropland disposal, the rate at which soil and crops can receive water is a consideration.

   i. A small capacity pump is less expensive, but may require more labor and time than a larger pump.

   ii. Semi-solids with up to 15 percent solids can be pumped. Solids and liquids separate in storage, so agitate wastes before pumping. Open impeller chopper pumps are often used to agitate semi-solids in storage.

   iii. Piston, helical rotor, submerged centrifugal and positive displacement gear-type pumps handle heavy semi-solids against high pressures, but their performance is better if solids are below about 10 percent. Priming is not required, so they adapt to automation.

3. Custom application has the potential problem of the applicator not being available at precisely the time when the manure needs to be hauled. This can be offset by the benefit of having good waste handling equipment available without the high investment and operating expenses involved in owning equipment that is used only a few days a year. Rates charged vary with location, but are usually about equal to the value of the nitrogen, phosphorus, and potassium fertilizer nutrient value contained in the waste.

4. Irrigation equipment disposes of wastes and also adds water and fertilizer to crops.

   a. For relatively large amounts of wastes, irrigation systems are economical and labor saving.

   b. Most irrigation systems can handle liquid wastes with up to 4 percent solids.

Use TM: A7–9C, A7–9D and A7–9E to illustrate flooring types and spreader components. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use text material to strengthen student understanding of concepts. Chapter 3, 6, 7, 8, 9 in Livestock Waste Facilities Handbook and Section 2 in Fertilizer and Manure Application Equipment are recommended.

Objective 4: Describe the calibration of waste management systems.

Anticipated Problem: How are waste management systems calibrated?

IV. When applied to soils in proper amounts, manures improve fertility and crop yields.

A. Since the beginning of recorded agriculture, it has been noted that manured crops grew better than crops without manure.

1. Due to large variations among farms, manure sampling for nutrient content is recommended in place of relying on average table values.

2. Reliable manure analysis is required for proper nutrient management planning, and proper sampling techniques at the farm. Manure analysis techniques in the laboratory are necessary for accurate results.

B. Poorly handled, manures can degrade surface and groundwater quality and cause nuisance conditions.

   1. An ideal application rate strategy for liquid manure should address current environmental concerns while promoting the economic well-being of the farm.
   2. Nutrient based manure application rates have one objective, the efficient recycling of manure nutrients.
   3. Soil physical properties affect application rates of manures. Water infiltration, water holding capacity, soil texture, and total exchange capacity influence application rates.
   4. Application rates are based on crop nutrient requirements and the approximate nutrient value of applied manure.
   5. There are several methods of monitoring liquid manure application rates in the field. Regardless of the method, monitoring should be used to calibrate manure applications to obtain the correct rate. Other considerations include the use of:
      a. Equipment manufacturers performance tables.
      b. Doppler or magnetic inductive electronic flowmeters with instantaneous readout and totalizer.
      c. Measuring the level of the storage facility before and after pumping.
      d. Using ground sheets or tarps to collect representative manure volumes in the field during land applications.
      e. Using pump curves to estimate the pump flow rate from engine rpm and measured pump discharge pressure.
   6. Record keeping is necessary for the manager who wants to document exactly how manure nutrients were managed and utilized.
      a. As part of compliance with federal, state, and local regulations, accurate records of all land applications must be kept.
      b. Good records showing sound practices will help to discourage a lawsuit or defend against a nuisance complaint.
      c. A good record keeping system can help assure that manure fertilizer nutrients are used effectively, while protecting groundwater and surface water resources. The level of detail will depend upon management style, and farming goals.

Use LS: A7–9A, LS: A7–9B and LS: A7–9C to reinforce student understanding of concepts. Use text material to strengthen student understanding of concepts. Chapter 3, 6, 7, 8, and 9 in Livestock Waste Facilities Handbook and Section 2 in Fertilizer and Manure Application Equipment are recommended.

Objective 5: Explain the maintenance procedures for waste management systems.

Anticipated Problem: What are the maintenance procedures for waste management systems?

V. Preventative maintenance should be given first consideration in the use of waste equipment in order to reduce to the chances for breakage, costly repair bills, and loss of time. Adequate and timely adjustment, repair, lubrication, protection from the weather, and clean-up determine the life of a machine.

A. It is important to select the proper lubricant for the different parts of machines. Consideration must be given to the function each part has to perform.

1. Secure a lubrication chart for the machine and follow its directions.
2. Inspect the crankcase oil and transmission grease. Fill or change according to the manufacturer's directions.
3. Use the proper equipment to lubricate the machines.
4. Inspect but do not molest or destroy the seal of parts operating in a "sealed for life" lubrication system.
5. Consult the operator's manual for lubrication instructions for the machine and for the location of the parts to be lubricated.

B. Due to the caustic nature of manure, timely clean-up is necessary.

1. Manure that is allowed to build-up will decrease the life of the material that it contacts.
2. High pressure washing is necessary to extend the life of manure handling equipment.

Use text material to strengthen student understanding of concepts. Chapter 3, 6, 7, 8, and 9 in Livestock Waste Facilities Handbook and Section 2 in Fertilizer and Manure Application Equipment are recommended.

Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle.

Application. The following lab activities will help students in applying the lesson's content:

LS: A7–9A—Sample Collection and Preparation
LS: A7–9B—Calculating Spreader Capacity
LS: A7–9C—Calibrating Spreaders

Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activity. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1 = d, 2 = b, 3 = c, 4 = a

Part Two: Completion

1. quality, composition
2. Record keeping
3. crop nutrient, nutrient

Part Three: Short Answer

1. Provide enough storage capacity to spread manure only when field conditions, labor availability, weather, and local regulations permit.
2. Economic, engineering, public reaction and regulation, and numerous factors related to agriculture and the operation.

Sample Test Name________________________________

Test

Lesson A7–9: Operating, Calibrating, and Maintaining Animal Waste Management Systems

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

a. anaerobic
b. earth basins
c. pits
d. semisolid

_______ 1. Manure with excess liquids drained off and some bedding added to increase solids content.

_______ 2. Earth-walled structures formed by excavation and earth berms so they are generally partly above and partly below grade

_______ 3. Have vertical sidewalls, are lined and are below grade

_______ 4. Occur without free oxygen and liquefy or degrade high biochemical oxygen demand wastes.

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. The _______________ and __________________ of wastes produced influence livestock waste facility design.
2. ______________ ______________ is necessary for the manager who wants to document exactly how manure nutrients were managed and utilized
3. Application rates are based on __________________ requirements and the approximate _______________ value of applied manure.

Part Three: Short Answer

Instructions. Provide information to answer the following questions.

1. How much manure storage capacity is necessary?

2. What should the selection of a waste management system be based on?

MANURE AND WASTE FACTORS

Operation

- Size and type
- Capital
- Mechanization level
- Owner preferences

Farm

- Size
- Soil type
- Topography
- Crops

Regulations

Proximity to neighbors

Climate

- Precipitation (amount, distribution, evaporation)
- Temperature norms
- Prevailing winds

Animal

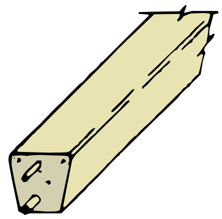
- Species
- Ration
- Housing
- Management
- Manure characteristics

NUTRIENTS IN LIVESTOCK WASTE

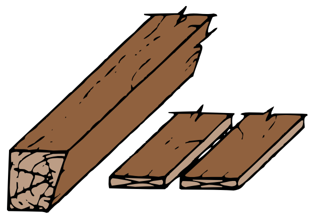
Animal	Size (lb)	N (lb/yr[a])	P_2O_5 (lb/yr[a])	K_2O (lb/yr[a])
Dairy cattle	150	23	11	18
	250	39	15	33
	500	78	33	62
	1,000	155	62	124
	1,400	217	88	175
Beef cattle	500	62	47	55
	750	95	69	80
	1,000	124	91	110
	1,250	157	113	139
Cow		131	100	114
Swine				
Nursery pig	35	7.3	4.4	4.4
Growing pig	65	11	8.0	8.4
Finishing pig	150	26	18	20
	200	33	24	26
Gestating sow	275	26	18	18
Sow and litter	375	37	20	20
Boar	350	33	23	23
Sheep	100	15	7	14
Poultry				
Layers	4	1.06	0.91	0.51
Broilers	2	0.88	0.62	0.33
Horse	1,000	110	59	110

[a]lb/yr = lb/day × 365 × animal weight ÷ 1,000

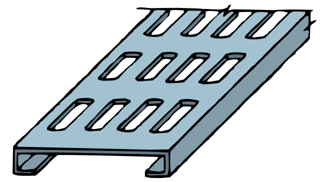
SLOTTED FLOORING TYPES



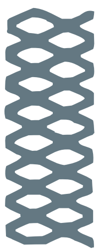
Reinforced Concrete



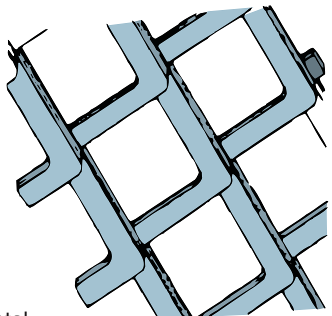
Wood



Punched or Perforated Plastic or Steel

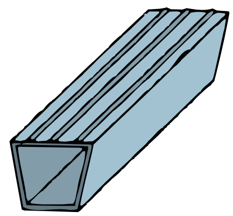


Expanded Metal (Flattened)

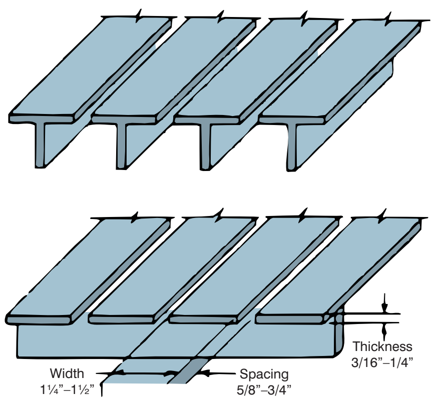


Expanded Metal (Unflattened)

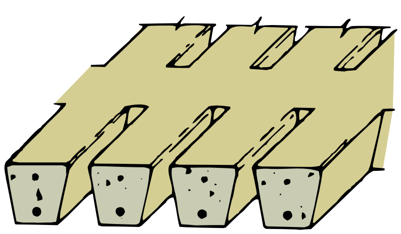
Woven Wire

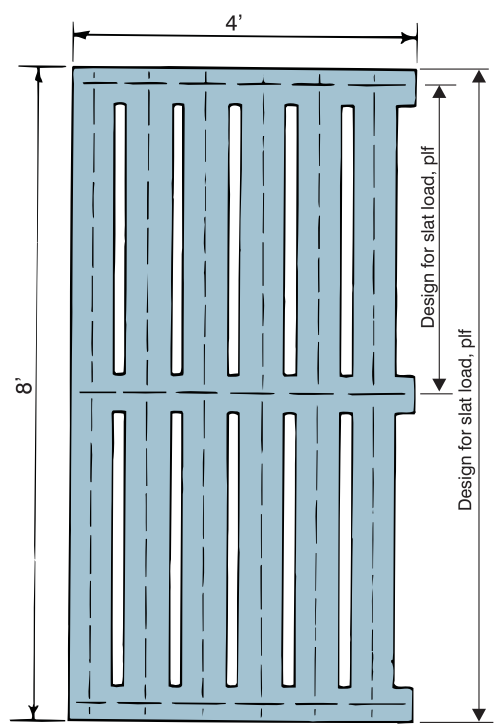


Extruded Aluminum, Fiberglass, or Plastic



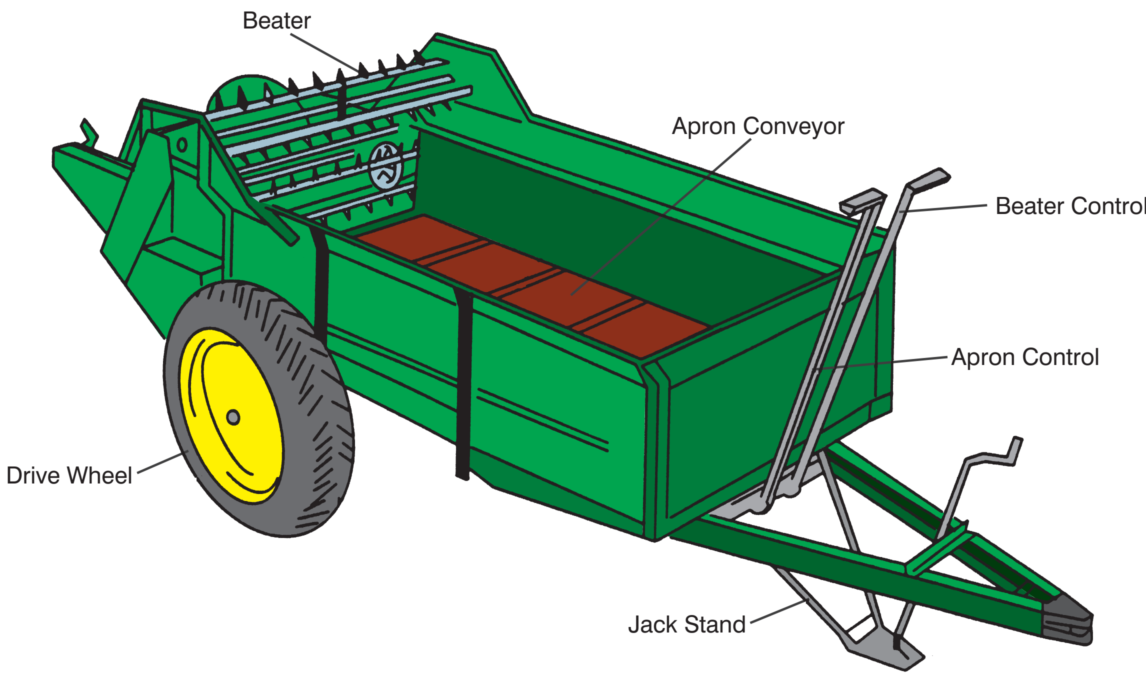
Steel or Aluminum Bars, Straps, or Ts

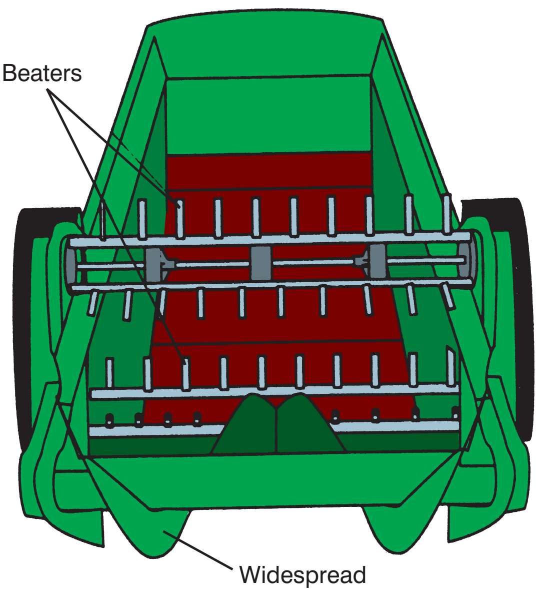




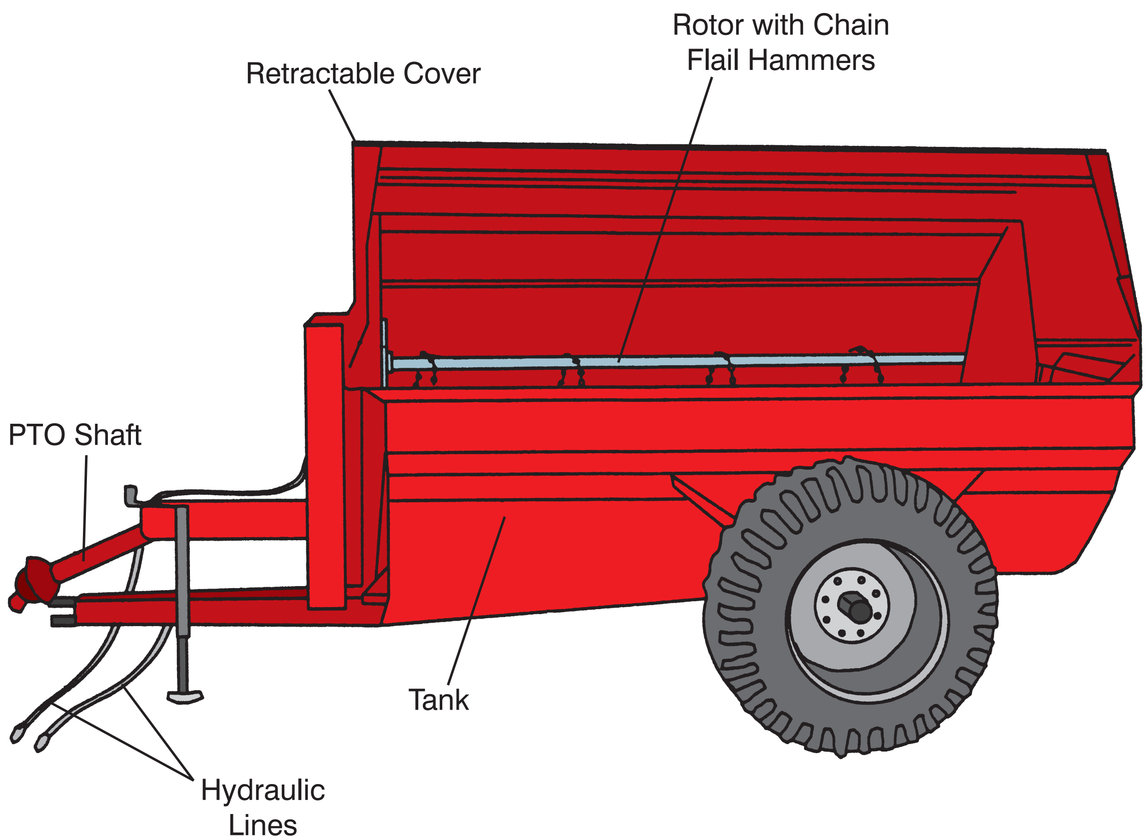
Reinforced Concrete Gang Slats

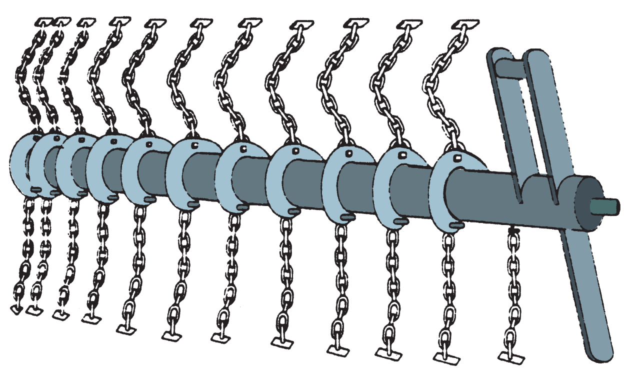
MANURE SPREADER COMPONENTS





FLAIL SPREADER COMPONENTS





LS: A7–9A Name ______________________________

Lab Sheet

Sample Collection and Preparation

Equipment:

large institutional-sized, long-stick, five-gallon bucket, and sampling bottle

Procedure:

1. Thoroughly agitate the liquid manure in the storage or tank spreader before sampling.
2. Collect a random sample directly from the storage or tank spreader using a large institutional-sized can nailed to a long stick. Take samples at several depths by plunging to a depth and then pulling up and down to mix. Put several of these volumes into a five-gallon pail. (Use caution when collecting samples. Do not hang into a closed storage to get a sample, dangerous gases are present that could cause sickness or blackout.)
3. Mix contents in the five-gallon bucket and remove a small amount of sample with a dipper.
4. Place the sample in a clean, tightly capped plastic bottle. Do not fill the bottle more than ¾ full to allow for gas generation and subsequent expansion.
5. If the sample cannot be quickly delivered to the laboratory, freeze the sample, especially when lab analysis will be delayed for more than a week.

 Name______________________________

Lab Sheet

Calculating Spreader Capacity

Equipment:

Manure spreader, feed lot, measuring device and calculator

Procedure:

1. Determine the amount of manure to be spread, expressed in cubic feet.
   a. The manure to be spread is found by determining the square feet and multiplying by the average depth.
   ________ (width in feet) × _________ (length in feet) = __________ square feet
   ________ square feet × _________ (depth in feet) = __________ cubic feet of manure
2. Determine the spreader capacity, expressed in cubic feet.
   a. The capacity of the spreader is found by determining the square feet of the spreader box and multiplying by the depth or height of the spreader box.
   ________ (width in feet) × _________ (length in feet) = __________ square feet
   ________ square feet × _________ (depth in feet) = __________ cubic feet spreader capacity
3. Determine the number of trips required to spread the manure.
   a. Number of trips equals the volume of the manure to be spread divided by the spreader capacity.
   _______ cubic feet of manure / _______ cubic feet spreader capacity = _______ trips
4. To convert between pounds and gallons, use the following:
   gallons per load = cubic feet × 7.5

   tons per load = gallons × 8.3 / 2000

 Name________________________________

Lab Sheet

Calibrating Spreaders

Equipment:

Manure spreader, measuring device, stakes or flagging, plastic sheeting or tarps, stop watch, calculator

Procedure:

1. Using the procedures learned in Lab: A7–9A, determine spreader capacity in tons or gallons.

   _________ cubic feet × 7.5 = capacity in gallons per load

   _________ gallons × 8.3 / 2000 = capacity in tons per load

2. Alternatively, place plastic sheets or tarps on the ground to collect the manure spread during the test application. Weigh manure collected in sheets or tarps.

   _________ = weight of manure collected

3. Determine and record the travel speed during the test application. Lay out a know distance in the field you intend to spread or in a field with similar surface conditions. Suggested distances are 100 feet for up to 5 MPH, 200 feet for speeds from 5 to 10 MPH, and at least 300 feet for speeds above 10 MPH.

   a. At the engine throttle setting and in the gear you plan to use during spreading with a loaded spreader, determine the travel time between the measured stakes in each direction. If the manure is injected, the applicator must be lowered into the ground during this step. Average the speeds.

      ______ travel time first pass + _____ travel time second pass = _____ total travel time

      ______ total travel time / 2 = _______ average travel time

b. Use the following equation to determine ground speed.

   Speed (MPH) = <u>distance (feet) × 60</u>

   time (seconds) × 88

   ______ MPH = <u>___________ × 60</u>

   _______ × 88

4. Use a tape to measure either the distance traveled during the test application or the square footage of the ground tarp collecting surface.

   _________ = distance traveled

5. Measure the average width of spread. Do not include sparsely covered edges.

   _________ = width of spread

6. Multiply the total length of spread by the average width of spread, in feet. Divide this number 43,560. This gives the number of acres covered in the test area.

   _______ length of spread × _______ width of spread = __________ area covered (sq. ft.)

   _____________ area covered (sq. ft.) / 43,560 = ___________ acres covered

7. The amount applied per acre, in tons or gallons per acre equals spreader capacity or amount spread divided by areas covered.

   _______ spreader capacity / ________ acres covered = _______ amount applied per acre