Unit D: Agricultural Equipment Systems

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

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 system.
5. Explain the maintenance procedures for waste management systems.

Recommended Teaching Time: 2 hours

Recommended Resources: The following resources may be useful in teaching this 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
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student worksheets
- Examples of manure handling equipment

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slide 2):

- Anaerobic
- Earth basins
- Pits
- Semi-solid manure

Interest Approach:

Discuss the importance of waste management with the students by asking them about what happens to waste that comes from their animals and/or humans. Why is it important to have a waste management system on farms or in villages?

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?

(PowerPoint Slide 3)

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.

(PowerPoint Slide 4)

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.

(PowerPoint Slide 5)

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.

(PowerPoint Slide 6)

C. 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. Regulations apply to all operations over a certain size or those that discharge wastes into surface or ground water.

3. Additional or more stringent requirements may be imposed, 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: 9-1 (PowerPoint Slide 7) to highlight manure and waste factors. Discuss how these factors affect the manure and waste and the procedures for disposing of these.

Objective 2: Identify animal waste characteristics.

Anticipated Problem: What are the characteristics of animal waste?

(PowerPoint Slide 8)

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

(PowerPoint Slide 9)

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.

Discuss the different types of waste and the disposal practices for those.

Objective 3: Explain operating practices used in animal waste management.
Anticipated Problem: What are the operating practices used in animal waste management?

(PowerPoint Slide 10)

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

(PowerPoint Slide 11)

A. When selecting a collection system, consider the type of facility, labor requirements, investments, 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.

(PowerPoint Slide 12)

      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.

(PowerPoint Slide 13)

      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 8.5 percent can cause footing problems.

(PowerPoint Slide 14)

   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.

(PowerPoint Slide 15)

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.

(PowerPoint Slide 16)

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.

(PowerPoint Slide 17)

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 under 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 1 meter 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 30 meters between a water supply and the nearest part of 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.

(PowerPoint Slides 18, 19, and 20)

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 beams. They are generally partly above and partly below grade. They may or may not be lined. The advantages of earth basins are:
      1) They provide long-term storage at low to moderate investment.

2) They are designed and constructed to prevent ground and surface water contamination.
3) They eliminate the problem of hazardous gas entrapment and reduce the potential for fatalities.

(PowerPoint Slides 21, 22, and 23)

c. Above-ground manure tanks are circular silo types or rectangular structures.
   1) They are more expensive than earth basins and are usually not used to store runoff or dilute wastes.
   2) They offer a good alternative where basins cannot be used due to site limitations or aesthetics.
   3) 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.
   1) ***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.
   2) Well designed lagoons give off a musty odor.
   3) Anaerobic lagoons handle high loading rates but give off some septic odors.
   4) Anaerobic lagoons liquefy and breakdown manure solids, but not all wastes added are completely degradable. Sludge accumulation depends on management, environment, waste characteristics, and loading rate.

(PowerPoint Slide 24)

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.
      1) 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.
      2) A picket dam removes only rainwater that falls on the storage; it does not reduce the water content of the manure.

(PowerPoint Slide 25)

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.

(PowerPoint Slides 26 and 27)

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.

(PowerPoint Slide 28)

    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 through 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.
            1) A small capacity pump is less expensive, but may require more labor and time than a larger pump.
            2) 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.
            3) 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 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.

Show TM: 9-2 (PowerPoint Slide 29) to illustrate the differing slotted floor types used in the confinement housing of animals. A large pit would be under the flooring to capture the waste. Discuss the advantages and disadvantages of each. TM: 9-3 (PowerPoint Slide 30) explains manure spreader components. Use TM: 9-4 (PowerPoint Slide 27) to illustrate flail spreader components. Discuss how these two types of spreaders are similar and different.

Objective 4: Describe the calibration of waste management systems.

Anticipated Problem: How are waste management systems calibrated?

(PowerPoint Slides 31 and 32)

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 and 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.

(PowerPoint Slide 33)

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.

(PowerPoint Slide 34)

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 manufacturer's 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.

Discuss how record keeping relates to proper waste management practices. Be sure to touch on the effects on the environment if waste is not applied correctly to the land.

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

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

(PowerPoint Slides 35 and 36)

V. Preventative maintenance should be given first consideration in the use of waste equipment in order to reduce 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.

(PowerPoint Slide 37)

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.

(PowerPoint Slide 38)

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.

Discuss these procedures and how they relate to the procedures for other equipment.

Review/Summary: Use the student learning objectives to summarize the lesson. **(PowerPoint Slide 39)** 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.

Tie the review together with the interest approach by discussing the common practices and systems found in Afghanistan. What is a common system here? Why does that system work best? In what ways can the system become more efficient?

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

LS: 9-1 Waste Storage Practices

(Power Point Slides 19, 20, 22, and 23 show a few pictures of some common waste storage systems.)

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:

Matching

1. D
2. B
3. C
4. A

Fill-in-the-blank

1. Quality, composition
2. Record keeping
3. Crop nutrient, nutrient

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 regulation, and numerous factors related to agriculture and the operation.

Sample Test

Operating, Calibrating, and Maintaining Animal Waste Management Systems

Name: _____

Matching: *Match each word with the correct definition.*

a. anaerobic c. pits
b. earth basins d. semi-solid

_____ 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.

Fill-in-the-blank*: Complete the following statements*.

1. A _____ is considered to be series of events that occur regularly.
2. The _____ _____ describes the total swept volume of the engine cylinders as the pistons complete one stroke.
3. The _____ is the part of the engine block where combustion takes place.
4. Those engines producing less than 25 horsepower are considered to be _____ _____.
5. _____ _____ are one-way directional valves that allow the air-fuel mixture to enter the crankcase.

Short Answer*: Answer the following question*.

1. How much manure storage capacity is necessary?

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

TM: 9-1

MANURE AND WASTE FACTORS

Operation

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

Farm

- Size
- Soil type
- Topography
- Crops

Regulations

Proximity to neighbors

Climate

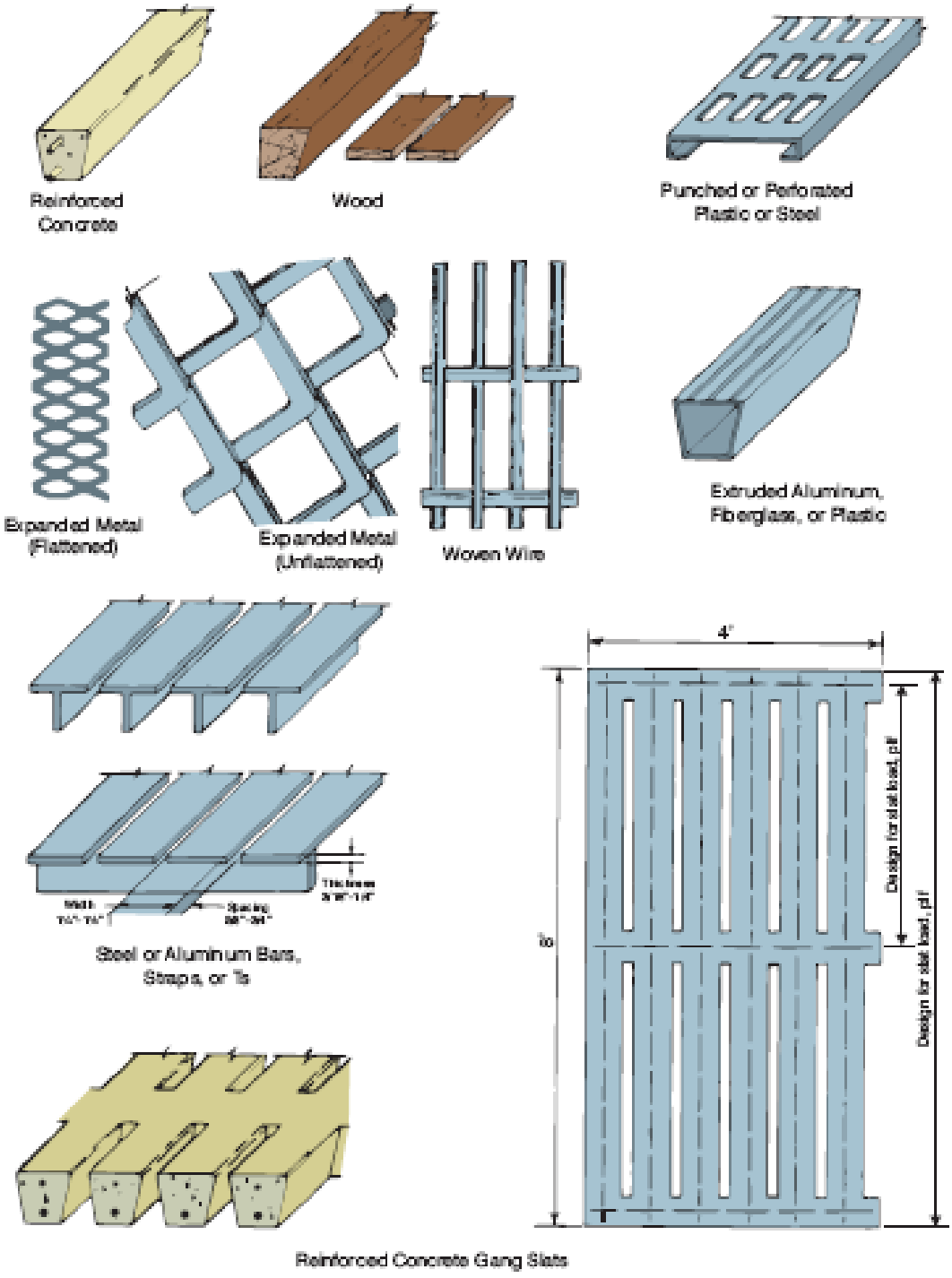
- Precipitation (amount, distribution, evaporation)
- Temperature norms
- Prevailing winds

Animal

- Species
- Ration
- Housing
- Management
- Manure characteristics

TM: 9-2

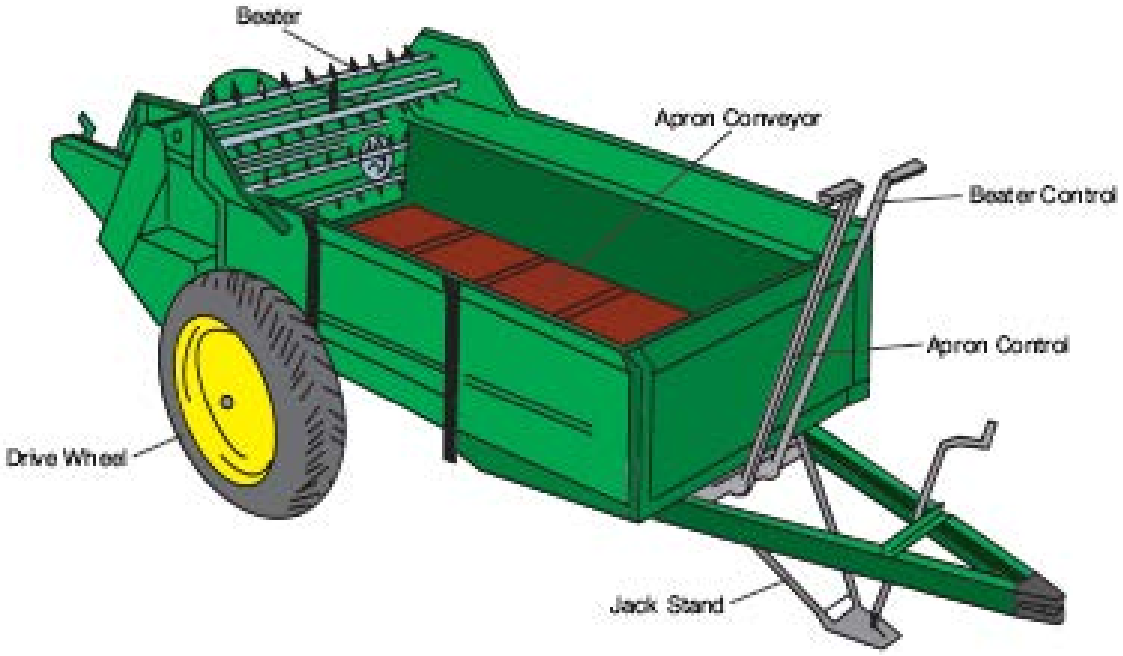
SLOTTED FLOORING TYPES

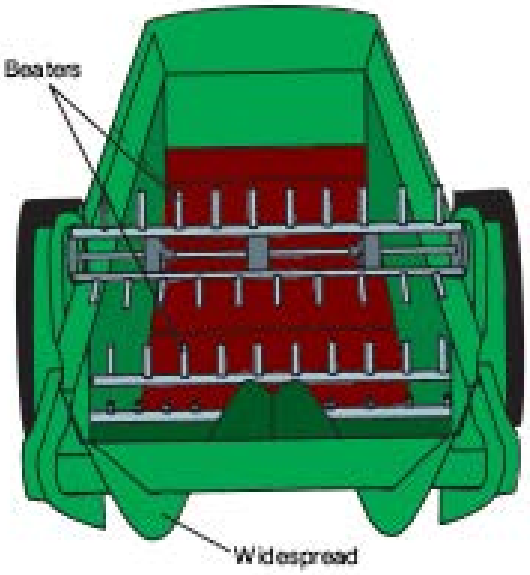


Reinforced Concrete Gang Slats

TM: 9-3

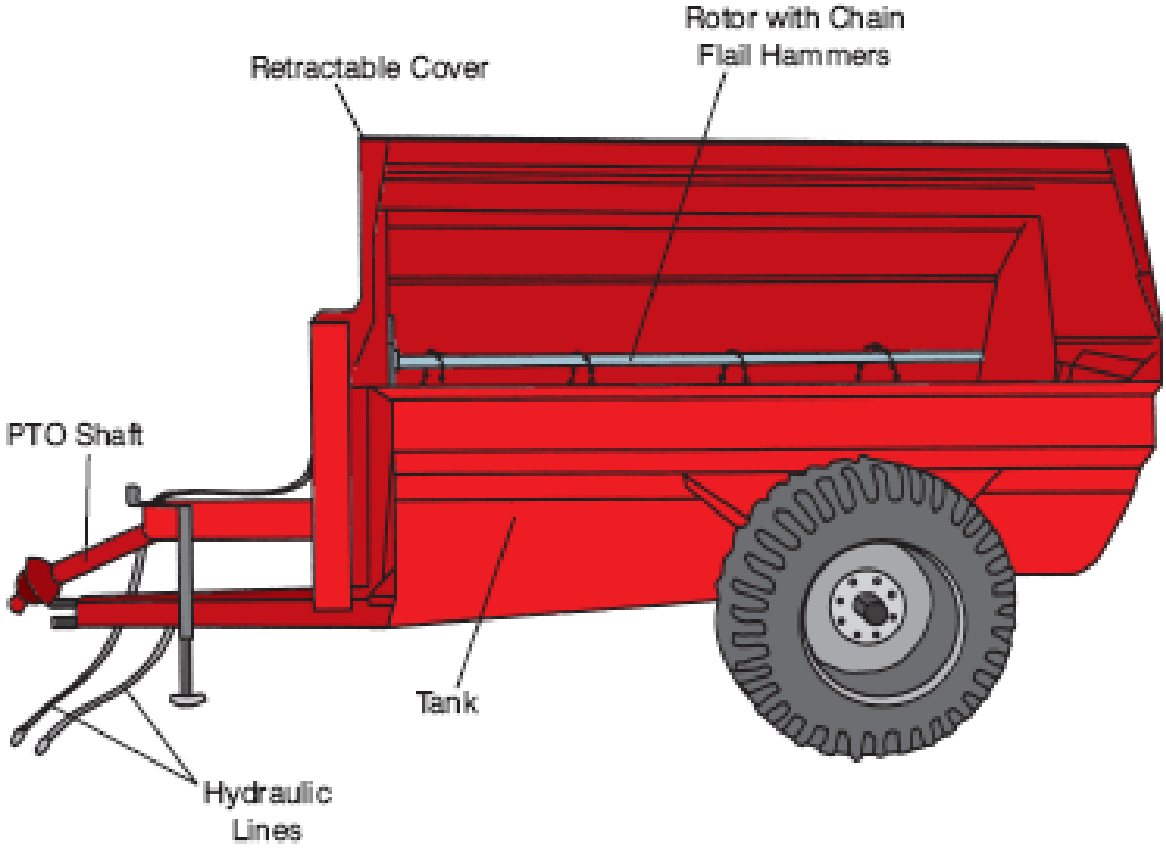
MANURE SPREADER COMPONENTS

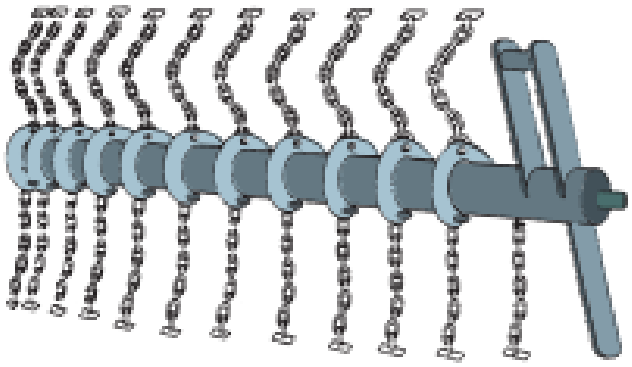




TM: 9-4

FLAIL SPREADER COMPONENTS





LS: 9-1

WASTE STORAGE PRACTICES

Divide students into groups of three or four and have them prepare a poster and presentation focusing on one type of waste storage practice.

Be sure to include the following:

1. Pictures or diagrams (several)
2. Description of waste storage system
3. What type of manure this waste storage system is commonly used for
4. How the waste, after storage in this system, is distributed
5. Advantages of this waste storage system
6. Disadvantages of this waste storage system

Possible storage systems:

Earth basin
Pit
Compost
Waste storage pond
Steel storage tank
Lagoon
Others with teacher's approval