Ohio's Animal Mortality and Slaughterhouse Waste Composting Manual

The Ohio State University Extension

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PREFACE

The 2022 revision of this manual reflects the evolution of animal mortality composting in the state of Ohio since the passage of Senate Bill 73, the “Dead Animal Composting Bill”, in 1994. At the time, the disappearance of rendering plants, concerns over burial and ground water pollution, disposal economics, and issues related to incineration challenged animal agriculture to discover innovative ways to dispose of livestock and poultry mortality. Senate Bill 73 made composting animal mortalities a legal disposal option at livestock and poultry farming operations without the need for solid waste disposal permits and licenses from the Ohio Environmental Protection Agency (Ohio EPA). Initially, the Ohio Department of Agriculture (ODA), Division of Animal Industry, and the Ohio Department of Natural Resources, Division of Soil and Water Conservation, were jointly responsible for implementing the on-farm mortality composting laws and regulations. In 2016, the Division of Soil and Water Conservation was transferred to ODA, thus consolidating all the responsibility for on-farm composting oversight into a single agency.

After the publication of the first version of this manual in January 2000, it became evident that the factors affecting the disposal of farm animal mortalities also affected the disposal of on-farm and off-farm slaughterhouse waste, and off-farm animal mortalities. This led to a collaboration between the Compost Research Facility at the Ohio Agricultural Research and Development Center (OARDC) and the Composting Program at Ohio EPA, to research how the principles of animal mortality composting could be adjusted for composting slaughterhouse waste. The findings of this research were later used as guidance by ODA and Ohio EPA for approving and monitoring composting of slaughterhouse waste. This 2018 revision of the manual incorporates for the first-time information specific to slaughterhouse waste.

In the mid 2000’s, Ohio EPA and various Ohio Department of Transportation county garages used this manual to establish facilities for composting road killed deer. These facilities allowed for trial modifications of available bulking agents (amendments), mixes, and less intensive management schedules that could be easily implemented by the agency local staff. The successful experience with these facilities led Ohio EPA to reduce permitting requirements and make it easier to compost off-farm mortalities.

ODA and Ohio EPA regulations require anyone intending to compost animal mortalities and slaughterhouse waste to attend a compost training session conducted by the Ohio State University Extension and obtain a certificate of completion. This manual, now renamed Ohio’s Animal Mortality and Slaughterhouse Waste Composting Manual, is the basis of the training certification. It has been designed to be used as resource material for the processes and procedures required for composting animal mortalities and slaughterhouse waste from approved animal species, as well as for the use of compost product on and off farm.

The information in this manual, as well as attendance at a training session, will allow your operation to expand disposal options, and enable improved efficiency and profitability. The manual will be appended as additional information becomes available, as new procedures are developed and approved, or as other species are added to the list of those approved for composting.

CHAPTER 1

Mortality and Slaughterhouse Waste Composting Principles and Operation

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This chapter is an overview of the principles of composting and the recommended management practices for composting animal mortalities and slaughterhouse waste.

Principles of Composting

Basics of Composting

Composting is a natural biological process of decomposition of organic materials in a predominantly **aerobic** environment. During the process, bacteria, fungi and other microorganisms break down organic materials to a stable mixture called compost while consuming oxygen and releasing heat, water, and carbon dioxide (CO_2). The finished compost resembles humus and can be used as a soil amendment. Composting reduces the volume of the parent materials and pathogens are destroyed if the process is controlled properly.

Microorganisms involved in composting can be classified according to temperatures most favorable to their metabolism and growth. The mesophilic (50 – 110 °F) and thermophilic microorganisms (110 – 160 °F) are the principal groups. A simplified view of the composting process is shown in Figure 1-1.

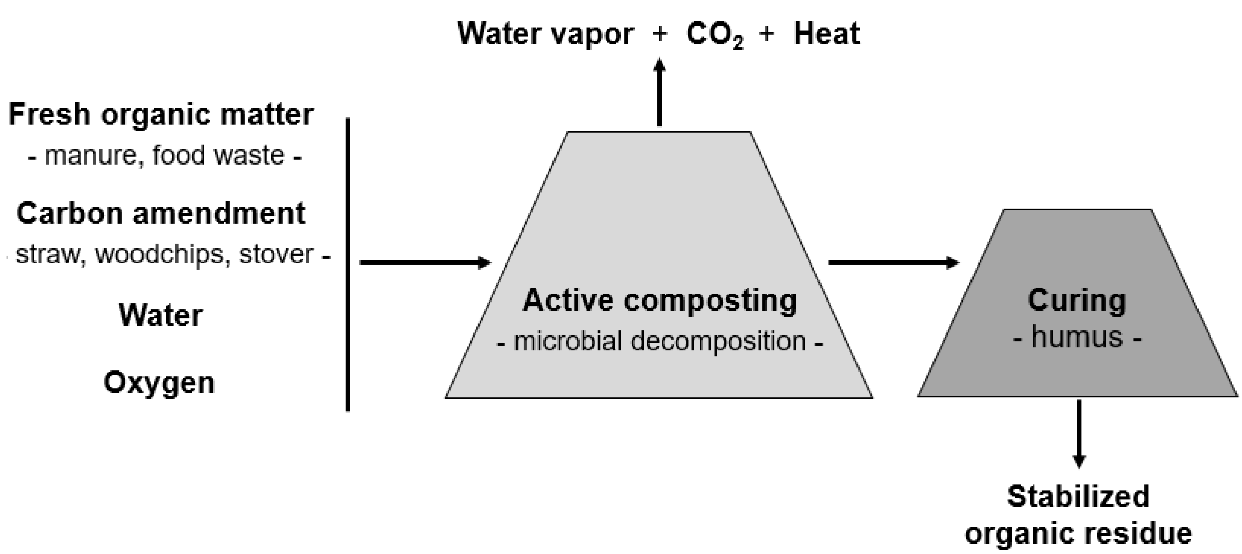

Figure 1-1. Simplified overview of the conventional composting process showing the material flows and breakdown of organic material to water, CO_2, heat, and compost.

In conventional composting processes, raw materials are brought together, mixed, and then put into a pile to initiate the compost process. Generally, the materials are mixed or turned every three or four days to introduce air into the system and speed the compost process. In some cases, mixing may occur daily, weekly, or monthly. Also, air can be forced into the compost to control temperature and keep the pile supplied with oxygen. When little or no heat is measured within the pile, the composted material is removed, re-mixed, and put in a curing pile for several months.

Under controlled conditions, composting is accomplished in two main stages: (1) a composting stage and (2) a curing stage. Figure 1-2 depicts these two stages. The composting stage involves three sub-stages:

a. An initial stage lasting 1 to 3 days, when mesophilic microorganisms degrade constituents such as sugars, starch, proteins, etc., and compost temperature rises rapidly.
b. A high-rate thermophilic stage, lasting 10 to perhaps 100 days, in which temperatures rise above 110 °F and fats, hemicellulose, cellulose and some lignin are degraded and pathogens are destroyed.
c. A stabilization stage, lasting 10 to 100 days during which the temperature declines and further degradation of cellulose, hemicellulose and lignin occurs.

The high-rate primary stage is accompanied by high rates of oxygen uptake and CO_2 output. Ammonia (NH_3) and other gases may evolve from the process if operating conditions are not well-controlled. During curing, or maturation, mesophilic organisms re-colonize within the composted material. Length of curing time for conventional composted materials depends on market and or land application opportunities, but typically is a minimum of one month and can extend up to six months.

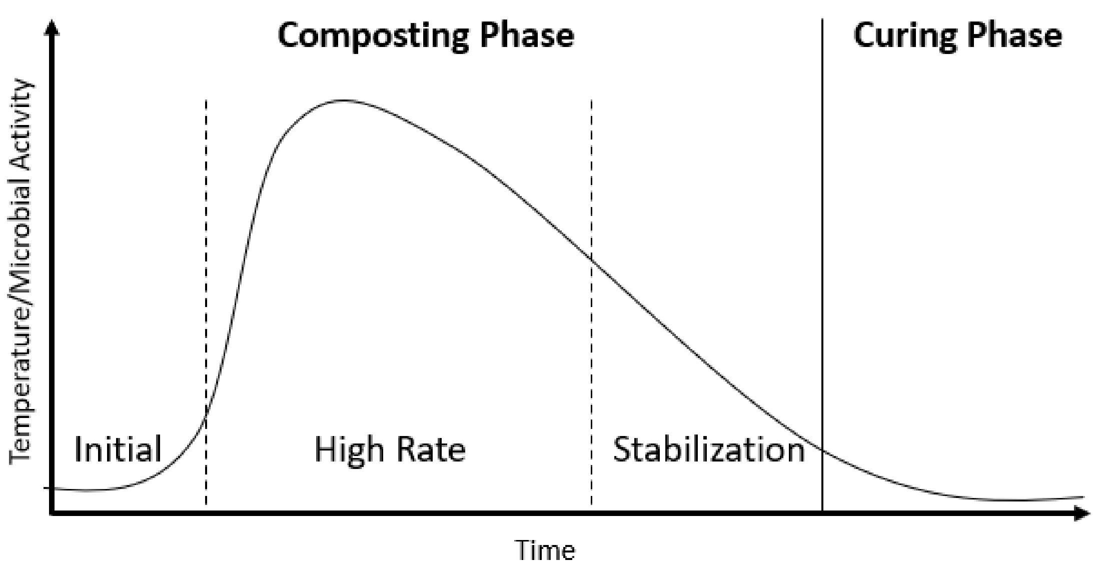

Figure 1-2. Stages of the conventional composting process.

While composting occurs naturally, the process requires proper conditions to occur at a desirable rapid rate, where odor generation is minimized and nuisance problems are alleviated. Over 20 controllable factors affect the success of the compost process. Table 1-1 lists eight of the most common factors and the acceptable ranges to aim for when composting. Of the eight factors listed, the four primary factors that need to be controlled in the composting process are the **material mix (nutrient balance)**, **water content**, **porosity**, and **temperature**.

Table 1-1. Guidelines for composting- major factors.

Factor	Reasonable Range	Preferred Range
Nutrient balance, C/N	20:1-40:1	30:1 - 35:1
Water Content	45-65% w.b.*	50-60% w.b.
Particle Size	0.8-1.2 cm (1/8-1/2 inch)	Depends on material
Porosity	30-50%	35-45%
Bulk Density	<640 kg/m^3 (1100lb/yd^3)	<640 kg/m^3 (1100lb/yd^3)
pH	5.8-9.0	6.5-8.0
Oxygen Concentration	>5%	> 10%
Temperature	45 - 68 °C (110-155 °F)	54 – 66 °C (130-150 °F)

* wet basis

Material Mix (C/N)

The compost mix requires both carbon and nitrogen at a ratio (C/N), which will provide an environment where microorganisms flourish and will result in a composting process that generates little odor. Generally, an initial C/N ratio of 20:1 to 40:1 is satisfactory. Most farm compostable materials have a C/N ratio that is too low to compost properly on their own. To compost these materials, amendments that contain a high C/N ratio must be added. Plant materials such as wood chips, sawdust, chopped corn stover, or straw have a high C/N ratio for on-farm composting.

Water Content & Porosity

Like all living things, microorganisms need water. To encourage their growth and rapid composting, water content of the mixture should be 50 to 60% (wet basis). It is important to avoid excess water because of the potential for odor and leachate conditions. **If the mixture feels moist, yet when a handful is squeezed no water drips from it, the mixture probably has adequate water content.** Composting in the open air is affected by rainfall and, in some regions, rainfall saturates compost piles. This results in leachate formation, odors, and other problems. In dry regions and in covered facilities, water must be added to avoid process inhibition.

Microorganisms that are encouraged to grow in a compost pile are aerobic or require oxygen. Open spaces (porosity) must be maintained to allow air to penetrate and move through the pile providing oxygen. Ideally 35 - 45% of the pile volume should be small open spaces. Optimum porosity is achieved by balancing the material particle sizes, water content of the mix, and pile size.

Temperature
The composting process will generate and regulate its own temperature. However, to maintain high temperatures the pile must be large (~3 ft x 3 ft x 3 ft) or have some insulation. A layer of inactive material, sawdust or finished compost, placed over the entire pile will insulate the pile. The insulation layer should be a foot or more thick. As the pile heats up, warm air within the mixture will rise and move out of the pile, while fresh air will be drawn in to replace it. This process exhausts CO_2 created in the pile and maintains an aerobic environment for the microorganisms.

The highest rates of decomposition occur for temperatures in the range of 110 – 150 °F. Temperatures above 131 °F for three days will kill parasites, and fecal and plant pathogens within the pile. However, at temperatures above 150 °F, microbial activity declines rapidly as compost temperatures exceed 160 °F. More information on composting can be found in the reference material cited at the end of this manual.

Animal Mortality Composting

Discussions and articles on composting animal mortality almost always gravitate toward satisfying the principles mentioned above. Unfortunately, strict application of those standards should only be done when dealing with a consistent, thoroughly mixed pile. The reality is that a pile in which animal mortality is composted is an inconsistent mixture. Therefore, composting animal mortality must be approached in a slightly different way.

Figure 1-3 is a schematic showing the process for composting animal mortality. This approach has been very successful on farms throughout the U.S. The compost pile (either open or in a bin) is an **inconsistent mixture** with a large mass of material (the animal) having a low C/N ratio, a high moisture content, and nearly zero porosity. The animal is then surrounded by a material (the carbon amendment) with a high C/N ratio, moderate moisture level, and good porosity. The animal and amendments are **layered** into the pile, and **mixing is done** in this process only **after the high-rate stage of composting** has occurred and the animal has fully or nearly fully decomposed. Composting animal mortalities (primary stage) can best be described as **"above ground burial in a bio-mass filter with pathogen kill by high temperature."**

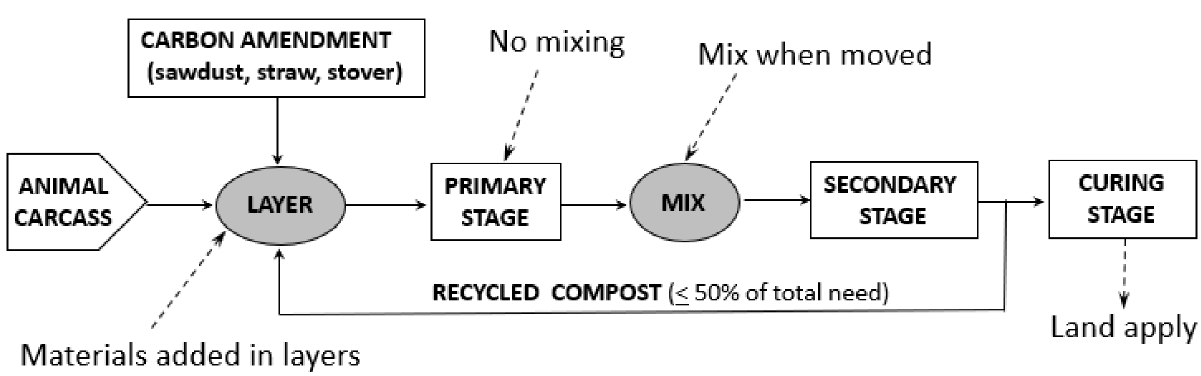

Figure 1-3. Material flow in animal mortality composting. Forced aeration is not used. Materials are not mixed until flesh of the animal body is completely decomposed. Time can vary from 10 days (poultry) to over 100 days (>400 lb. animal).

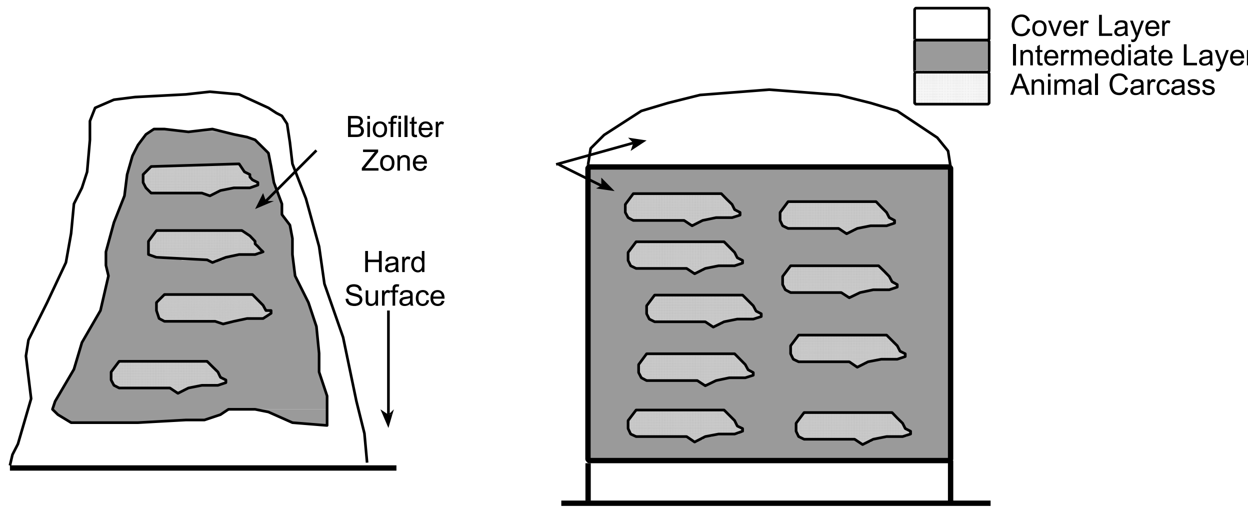

Figure 1-4. Cross-section views of composting in a windrow (pile) or bin for animal mortality—layering of animal mortality is essential and the mortality is then surrounded by organic amendments that provide carbon (energy) for the microorganisms and act as a biofilter material. Piles or bins are not turned until animal flesh is decomposed. Pile shape will depend on whether it is in the open (windrow approach) or in a bin with designated side walls.

Figure 1-4 is a cross section of an animal mortality compost pile. The decomposition process is anaerobic (lacking oxygen) in and around the animal mortality. But as gasses are produced and diffuse away from the mortality, they enter an aerobic zone. In the aerobic zone, the gasses are trapped in the surrounding material, ingested by the microorganisms, and degraded to CO_2 and H_2O. Thus, the surrounding material supports bacteria to form a biological filter, or biofilter, to reduce odor emissions during decomposition.

With mortality composting, turning and mixing of the pile is avoided until the mortality (flesh and many small bones) has been decomposed. For moderate-sized animals (poultry, pigs, sheep, goats, or young animals) the length of time required for the primary or high-rate stage of decomposition is generally less than three months after the last mortality has been placed into the pile. Following the primary stage of decomposition, the compost is moved, turned, or mixed to form a secondary area or stage where any bones and flesh remaining are allowed to complete the compost process. The secondary stage will require 10 days to several months, depending on the size of bones and the amount of material that the microorganisms must decompose. Moving the primary stage pile or bin to the secondary composting stage introduces air back into the pile and mixes the contents of the pile, leading to more uniformity in the finished compost and completion of the degradation process. Following completion of the secondary stage, the compost is turned and placed into a curing/storage phase for 30 days or more. When composting large, mature animals, bones sometimes remain after completion of the secondary and or storage stages. These bones are usually quite brittle and pose no health risks or danger to equipment when land applied. In some instances, it may be desirable to recycle the larger bones back into the compost pile to allow more decomposition.

Data Collection

To monitor the composting process, it is necessary to measure and record temperatures of the compost pile. **Progression of the mortality composting decomposition process is measured primarily through temperature monitoring.** In addition, pathogen-kill can be monitored by measuring the internal pile temperature. Temperatures should be taken at several points near where the animals are in the compost pile. Temperature recording can be done easily with a three-foot probe thermometer (¼ -inch probe diameter is recommended). Data recorded should include date, size, number of animals added, and the internal temperature of the pile. Temperature is the single most valuable information available to determine the degradation stage and to identify when to turn and mix the pile. Temperatures below 110 °F or consistently declining pile temperatures are indicators that the microorganisms have a limited food supply and or the pile conditions are not conducive to survival. Under either condition, the pile will need to be turned, mixed, water added, dry amendment added, or otherwise modified to complete the composting process.

Managing the Composting of Animal Mortality

There are two general approaches to animal mortality composting: enclosed or bin systems and open pile systems. Ohio Department of Agriculture (ODA) regulations specify bins only for poultry composting, but they allow either option for the other approved livestock species. The basic management fundamentals are outlined for both approaches in the following materials.

Sawdust is widely used as a bulking agent or amendment. It works well as a biofilter, allows high temperatures to be achieved and sustained during the primary stage, and promotes bone-breakdown when doing large (>400 lb.) animals. Because of its ability to shed rainwater, sawdust works well for outside piles where exposure to rain and snow could result in high moisture levels. Excess moisture can lead to leachate, a black/brown colored liquid that seeps from the pile or bin. Leachate needs to be avoided because it can cause water contamination and generate odor. When using sawdust, it is recommended that 25 – 50% of the material/amendment used to cover the mortality be in the form of recycled compost from the storage pile. Utilization of finished compost through recycling reduces cost, improves and increases the rate of the composting process, and leads to a higher quality finished compost. Recycle rates should not exceed 50% by volume of the amendment used in new or established compost systems. At recycle rates above 50%, carbon availability may be limited which can interfere with the composting process.

Ohio research has shown that: (1) mixtures of sawdust and chopped straw (or corn stover) can be used both under a roofed system and in outdoor, exposed piles; and (2) chopped straw or corn stover alone or in combination can be used in roofed piles, but these amendments often require periodic water addition during composting to maintain the compost process. If straw or corn stover is used in a compost mixture, the amount of recycled material that can be used will need to be reduced due to the lower carbon content. When composting poultry mortality, poultry litter and straw together work very well to initiate and sustain the compost process. Table 1-2 lists potential materials for use in composting animal mortality. Tthe suitability of amendment materials for different species and systems is discussed in other chapters of this manual.

Table 1-2. Carbon sources/carbon amendments identified for possible incorporation into animal mortality composting operations. (*Source: National Pork Producers Handbook*)

Corn stover	Chopped soybean stubble
Peanut hulls	Wood shavings/chips
Sawdust	Recycled paper/cardboard
Yardwaste	Leaves
Hay	Chicken litter
Rice hulls	Manure & bedding (horse, sheep, swine)
Straw	

Composting mortality practices are simple. The recommended steps are:

1. Construct a base from sawdust or acceptable amendment at least 1 foot thick. The base will need to be thicker (2 feet) for larger animals (>400 lbs). The base is designed to collect liquids that are released during mortality decomposition and serves to permit air movement and microbial action underneath the mortality. Often, low quality hay and or straw alone in combination with sawdust make a sufficient base. **Note:** If liquids (leachate) begin to leach out of the pile, spread sawdust around the pile to absorb the liquids **and** increase the depth of the base when constructing new piles.
2. Place a layer of animals on the base. A single layer of animals should be centered on, and evenly spaced, across the base. Do not stack animals directly on top of one another (with the exception of very small animals for which mortalities can be layered up to 4 inches thick). Four to six inches of amendment is necessary between layers of mortality for the compost system to work effectively
3. Cover the animals with 2 feet of damp amendment in outside or non-covered bins and a minimum of 1 foot of cover in roofed bin structures. This cover acts as the biofilter for odor control around the pile and insulates the pile to retain heat. Odors may be released when an inadequate cover is used or when the cover material is too dry or too wet. The released odors may attract scavenging animals and pets to the pile. Maintaining a 2-foot cover prevents problems to a large extent. In addition, when disposing of large animals, it is often best to place the mortality feet down to avoid legs and feet from being exposed.

When additional animals are placed in the pile these steps should be followed:

4. Hollow out a hole in the amendment (in the 2 feet of cover material). Maintain 4 - 6 inches of amendment over animals already in the pile.
5. Place a new layer of animals in the pile.
6. Cover the new layer of animals with 2 feet of damp amendment.

Pile (bin) management is a simple cycle, based on a **primary stage time** (T1), **secondary stage time** (T2), and **storage stage time** (T3). Times T1 and T2 are estimated based on size of the largest carcass in the pile or bin. Storage (T3) time is recommended to be a minimum of 30 days to assure final curing and to provide a window of opportunity for land application. A minimum of two primary piles (bins) are required for contained mortality composting. An alternative is the use of windrows where mortality is added in succession beginning with increasing the pile height followed by extension of the pile length. In either bins or windrows, there must be a primary compost area available that can handle the largest animals expected and the longest time expected to complete the primary compost stage. The secondary pile, bin, or windrow volume is the same size as for the primary stage and is used as an area to mix and turn the primary pile materials. For windrows with the proper equipment, many producers will turn and mix the windrow in place, requiring less overall space. Storage pile size is dictated by how long the compost will be stored before land application.

On most farms where multiple sized mortality are added to piles, each primary pile is loaded over a period of time. Once the final carcass is added, the pile is allowed to finish composting for T1 days. Then the pile is turned and composted for T2 days. Another primary stage area is loaded while the first pile is allowed to complete the primary stage. Thus, a cycle of two primaries, one secondary, and one storage area are needed for any given system. When materials are placed in the storage area (minimum of 30 days) they can either be hauled or added as recycled materials when building new primary stages. Additional information on design and operation is in chapter 3.

Composting Slaughterhouse Waste

Guidelines for composting slaughterhouse waste (a.k.a. raw rendering material) are similar to those for whole animals. The primary differences, which are due to the higher initial moisture content and dismemberment of the slaughterhouse waste (SHW), are in the construction and management of the pile. Table 1-3 shows the differences in the thickness of the amendment and the length of time for each composting stage. It is recommended that the base layer be comprised of a 12-inch layer of woodchips, which can improve aeration, covered by a 12-inch layer of dry sawdust or compost, which can absorb moisture. Other amendments can be used depending on whether the system is covered (see page 6).

Table 1-3. Comparison of slaughterhouse waste (SHW) and whole animal composting

Attribute	Unit	Slaughter-house Waste	Whole Animal
Amendment-cover	inches	12-24	12-24
SHW[1] or animal[2]	inches	6-18	Animal(s)
Amendment-b/t layers[3]	inches	6	6-12
SHW[1] or animal[2]	inches	6-18	Animal(s)
Amendment-base	inches	24	12-18
Stage 1 (primary)	days	35	10-194
Stage 2 (secondary)	days	35	10-65
Stage 3 (finishing)	days	35	30

[1] Place 6-12 in of amendment along the perimeter of the bin for the SHW layer.; [2]Only 1 large animal is placed in the pile, while smaller ones (chickens or hogs) may be layered. [3]b/t - between

For whole animals, the large variation in size affects the time required for each stage; whereas, SHW volume tends to be more consistent so there is less variation in time required. Because SHW consists of body parts, it is important to cover it quickly to reduce the risk of pathogens and odors. Bones that do not decompose in Stage 2 should be added back to a Stage 1 bin or windrow where they can help improve porosity and continue to decompose. Bins are typically used for SHW composting because they provide good control and limit access to potential scavengers. However, for large operations, windrow composting may be the best option for the volume of SHW generated. Details on bin system design are in chapter 3.

Composting Mass Mortality

The composting methods in this manual are not intended for disposal of large numbers of livestock or poultry mortality resulting from a disease outbreak or natural disaster. Should disposal of livestock that is significantly greater than the average daily load be required, it is recommended that you contact the regulatory agencies below for guidance. Note that if contagious or reportable diseases are suspected, **ODA and USDA must be contacted immediately**.

ODA Animal Health	614-728-6220	animal@agri.ohio.gov
USDA	614-856-4735	VSOH@usda.gov
Ohio EPA	614-644-2621	

Additional resources for managing mass mortality:

USDA APHIS Carcass Management Tools and Resources:
www.aphis.usda.gov/aphis/ourfocus/animalhealth/emergency-management/carcass-management/carcass-mgmt-tools-resources/carcass-tools-resources

USDA APHIC Carcass Management Dashboard:
www.aphis.usda.gov/aphis/ourfocus/animalhealth/emergency-management/carcass-management

USDA Foreign Animal Disease Preparedness & Response Plan | Standard Operating Procedures | Disposal:
www.aphis.usda.gov/animal_health/emergency_management/downloads/sop/sop_disposal.pdf

CHAPTER 2

Composting Site Selection & Design Options

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Ohio has identified four basic objectives that must be met when composting animal mortalities and slaughterhouse waste. These objectives are:

1. Protect ground and surface waters from pollution.
2. Reduce the risk of the spread of disease.
3. Prevent nuisances such as flies, vermin, and scavenging animals.
4. Maintain air quality.

Selecting the proper location and design for a composting facility are the first steps in meeting the objectives listed above. However, in review of existing composting facilities within the state of Ohio, a primary concern conveyed and observed has been improper site selection, which has led to limited access, scavenging animals, and odor complaints.

SITING GUIDELINES

Several factors must be considered when siting facilities for composting animal mortalities. Water quality, public perception, nuisance concerns, biosecurity issues, and traffic around the composting area are some of the primary factors.

Water Quality

A number of organic compounds are produced during the composting process. Some of these compounds, such as nutrients and bacteria, pose water quality problems if allowed to leach out of the compost and find their way into ground or surface waters. These problems are avoided by controlling leachate from the pile, managing runoff of wastewater and solids from the site, and establishing a composting base with low permeability.

Leachate Control

Leachate problems occur due to excess liquids escaping the compost pile. Leachate is best controlled by using adequate amounts of an absorbent-carbon amendment at the bottom of the compost pile. If leachate does occur, it must be collected and treated before entering a stream or other water resource. Treatment can take place through properly designed vegetative filter strips, infiltration areas, or other accepted treatment methods.

Runoff Control

Composting facilities should be located on high ground to avoid flooding problems and located away from streams, lakes, and wells to minimize the risk of polluted runoff entering water supplies. Off-site surface water should be diverted away from the composting facility to minimize the amount of runoff water generated from the compost site. If facilities will be located in areas subject to flooding, they must be protected **from a 25-year, 24-hour rainfall event**. Runoff from a non-roofed facility should be controlled and directed to a properly designed vegetative filter strip, infiltration area, or other accepted treatment method. Regardless of the method used, there must not be any discharge of polluted runoff to waters of the state. Consult your local Soil and Water Conservation District, Natural Resources Conservation Service office, or Ohio EPA District Office for more assistance.

Ground Water Protection
To protect ground water, the base of the composting facility should have a low permeability and be a minimum of 3 feet above the high-water table. A concrete or crushed rock base overlying a geo-textile cloth (low permeability) is recommended when the site has high permeability soil. These requirements help prevent water from leaching through the base of the composting facility into the ground water.

Biosecurity
Control of pathogens and disease are critical to any livestock operation. Traffic from the composting facility to production housing should be minimized and, if possible, eliminated. The composting process successfully destroys most diseases, but bacteria and viruses from fresh mortality can be passed through the transport vehicle to production housing. Collection of leachate should direct runoff away from production facilities. Scavenging animals and vermin must also be kept out of the compost. Maintaining the recommended cover (2 feet in outside piles, 1 foot in enclosed bins) over the compost pile should eliminate these problems. However, experience has shown that once scavengers know there are mortalities in the pile, they will dig into the pile to find them. Fencing should be installed around all compost piles and bins to aid in the elimination of scavenging animals. Greater detail on biosecurity is provided in chapter 5. In addition, any equipment used in moving animals or compost must be sanitized if is to be used for other operations.

Public Perception
Composting will generate little if any odor, flies, or other nuisances when **managed properly**. However, when siting the composting facility, consideration must be given to the location of neighboring residences, production facilities, and public roads and highways. Composting facilities should be located downwind of nearby residences. Aesthetics should also be considered; handling of dead livestock may not be a welcome sight to nearby residents or those passing by. Consider their view or area of sight when siting the facility.

Traffic
Depending on the size and management of the livestock facilities, animals may be added to the pile several times a week or every day. Ponding of water and mud will interfere with access to the composting area. To avoid these problems, construct a roadway that provides all-weather access to the compost area. Loading and unloading at the compost facility must be possible in all weather conditions. Areas around the composting facility that are used to unload finished compost must be firm and well drained. A solid base, such as gravel or concrete, is required in this area, and will help

prevent ponding water and accessibility problems from occurring around the compost facility.

Traffic flow to and from the compost area must be considered. Appropriate distances from overhead and underground utilities must be maintained to ensure safety. The composting facility should be located and constructed so as not to interfere with other farm operations.

A checklist of requirements for the composting area produced by the Natural Resources Conservation Service is given in Table 2.1. Refer to this checklist when comparing possible composting sites on your farm or business. Figure 2.1 shows a general layout for a composting site. Although all sites will be unique, this figure illustrates the general requirements for a composting site. Site selection for the composting facility is an important step in helping to protect water quality, prevent complaints and nuisance problems, maintain biosecurity, and minimize the challenges in operating and managing the composting process.

Table 2-1. Site selection checklist for livestock mortality composting facilities

Is the site:
- ✓ Away from ponding areas or drainage patterns (high and dry)?
- ✓ Able to divert clean water?
- ✓ At least 3 ft. above the high-water table?
- ✓ At least 300 ft. from streams, lakes, waterways, etc.?

Does the site have:
- ✓ Runoff collection and available treatment areas?
- ✓ All-weather access to the compost area?
- ✓ All-weather compost pad?

Does the location provide:
- ✓ Suitable access to sawdust storage?
- ✓ Clearance from underground and overhead utilities?
- ✓ Minimal interference with other farm traffic?

Is the producer considered:
- ✓ View from neighboring residences?
- ✓ Prevailing winds for the site?
- ✓ Biosecurity precautions?
- ✓ Aesthetics and landscaping

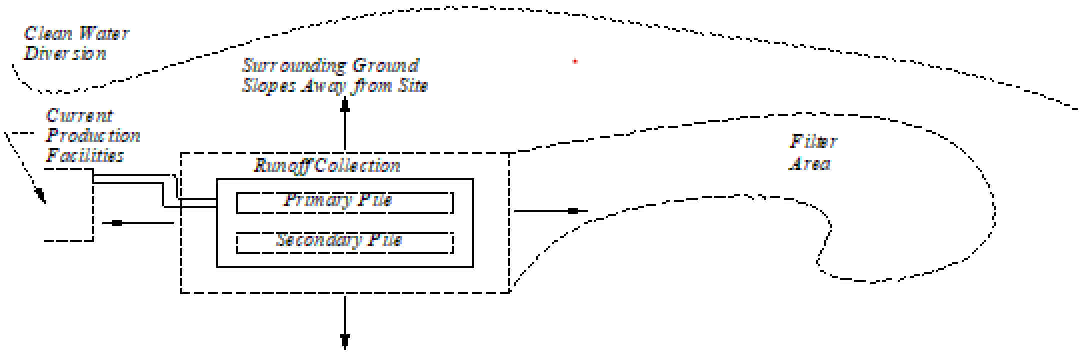

Figure 2.1. General site layout recommendations for composting facilities.

FACILITY DESIGN ALTERNATIVES

Mortality composting is commonly conducted in one of five primary facility types: a bin, static pile, windrow, mini-composter, or in-vessel composter. Each option has unique advantages and disadvantages, and producer choice is driven by several concerns, including:

1. Ability to meet the four objectives required of a compost system.
2. Type of production unit serviced.
3. Economic costs associated with startup and operation of the system.
4. State regulations and/or restrictions on facility type and design specifications.
5. Access to economical sources of carbon amendment.
6. Access to appropriate loading, unloading, and handling equipment.
7. Appropriate land area for application of compost material.

Given these driving factors, producers must make informed decisions based on the specific advantages of each facility.

Bin Composting

Composting in a bin usually involves construction of a facility with a concrete floor, wood or concrete sidewalls on at least 3 sides, and a roof over the facility to eliminate water infiltration.The ability to control moisture in the bin is a key to operational success. Maintaining the compost too wet will create odors, slow decomposition, and require addition of dry amendment by either removal of compost and mixing outside the bin or limited mixing within the bin.

Advantages to Bin Composting	Disadvantages to Bin Composting
+ Reduced risk of weather affecting the compost process.	- Initial investment in facilities.
+ More aesthetically pleasing appearance.	- Need for a water source.
+ Reduced risk of scavenging animals.	

+ Compost moisture content is consistent and controllable.	
+ Many carbon amendments can be used in the process.	
+ Leachate risk is reduced and easily contained.	
+ Existing facilities, barns, etc. may be easily modified to meet the needs.	

Windrow and Static Pile Composting

The windrow composting system is established on a concrete, geo-textile fabric-lined gravel base, or low permeable soil to control water infiltration. In this system, walls and roofs are not used, so the pile is usually accessible from all sides to load, unload and mix the compost materials. Producers using this design will load the livestock mortalities for a specific time period, continually extending the length of the compost pile. The compost material is mounded to shed rainfall, control moisture loss, and maintain adequate biofilter cover. Turning of any portion of the pile is delayed until the time requirements are met or temperature monitoring indicates acceptability within any stage: stage 1 (1st turn at T1), stage 2 (2nd turn at T2), or storage (T3 ≥ 30 days). The specific size and number of windrows will be based on management, site parameters for layout, and loading rates. These topics are discussed in chapters 3 and 4.

Static pile composting is similar to using windrows except the pile is not extended in length. Turning of any pile is delayed until it has met acceptable times for stage 1 (1st turn) or stage 2 (2nd turn) or storage (removal). With static pile composting there will be three active piles in operation at any given time (2 primary and 1 secondary).

Advantages to Windrow & Static Pile	Disadvantages to Windrow & Static Pile
+ Low initial investment in facilities.	- Exposure of the compost to the elements (wind and rain) increases risk of leachate and runoff.
	- Acceptable carbon amendment more limited than for bin system.
	- Scavenging animals, if present, may be difficult to eliminate.

Mini-composters

Mini-composters are a smaller version of a bin composter. Generally, these facilities are about 40 inches square and 36 inches high and handle disposal of very small animals and/or birth materials. Animal size is generally limited to less than 40 pounds and primary-bin requirements would typically be less than 70 cubic feet. During Ohio's winter months, some additional insulation may be needed to enable the compost to reach the desired temperatures (> 131°F) for pathogen destruction and effective degradation. When mini-composters are not covered or under roof, use the carbon amendments recommended for pile or windrow systems (e.g. sawdust). When mini-composters are inside a building or under their own protective roof, use carbon amendments recommended for bin composting (e.g. straw, litter/manure, sawdust or others). See Table 1-2 for more options.

Advantages to Mini-Composters	Disadvantages to Mini-Composters
+ Low investment cost.	- May lose effectiveness under low ambient temperatures.
+ Compact size.	
+ Fast degradation of small animals and birth materials.	

In-vessel Composter

In-vessel composters may be used for the primary stage. The most common ones are a large steel drum that is totally enclosed, with forced aeration. Mortality and amendments are loaded at one end and the drum turns slowly and/or uses paddles to agitate the material and move it to the opposite end. It is then removed to a bin or windrow for the secondary stage composting. The size of the composter selected should accommodate the largest animal to be composted as well as the average daily loss and carbon amendment per pound of mortality as suggested by the manufacturer. A list of in-vessel composters approved by the USDA-NRCS is at: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=34080.wba

Bins or windrows for the secondary stage must be designed to handle the output of the in-vessel composter when running at full capacity using the manufacturer's predicted rate for output volume per day. Consider what portion of the primary stage compost you expect to recycle back to the in-vessel composter as a carbon source.

Advantages to In-vessel Composters	Disadvantages to In-vessel Composters
+ Reduced risk of weather affecting the compost process.	- High investment cost
+ More aesthetically pleasing appearance	- Need access to electricity and water
+ Increased rate of the primary stage composting	- Additional space needed for secondary and storage stages
+ Continuous addition of mortality	- Additional space needed for storage or primary stage composting in case of operational malfunction
+ Reduced risk of scavenging animals.	
+ Compost moisture content is consistent and controllable.	
+ Many carbon amendments can be used in the process.	
+ Leachate risk is reduced and easily contained.	

This chapter was adapted from OSU Extension Factsheet AEX 712-97, Swine Composting Site Selection by Mescher, Wolfe, Stowell and Keener, 1997; OSUE Extension Factsheet AEX 713-97,Swine Composting Facility Design by Mescher, Wolfe, Foster and Stowell, 1997; and the NPPC Composting Module, McGuire (ed), 1997; USDA-NRCS, In-vessel Composters for Livestock Mortality Management, Technical Note No. 210-EEN-01, 2013; USDA-NRCS, National Engineering Handbook, 210 AWMFH Part 651, 210-I-AWMFH, Notice IL29, May 2017.

CHAPTER 3

Composting Facility Sizing

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Chapter 2 listed the four basic objectives for composting animal mortalities: protect ground and surface waters from pollution; reduce the risk of spreading disease; prevent nuisances such as flies, vermin, and scavenging animals; and maintain air quality. Meeting these objectives requires proper sizing of the compost facility. This chapter presents the basic formulas along with worksheets and graphs for sizing and specifying the design of composting facilities.

Sizing Guidelines

Sizing of a composting facility is critical for its successful operation. Composting facilities that are undersized will lead to problems with odor and flies. Proper sizing will make the management and operation of the composting process easier. Sizing is based on:

- Three stages for composting - primary, secondary, and storage.
- Weight of the largest animal in the primary composting stage.
- Daily mortality rate and composting time, which determines total loading for each primary bin or daily volume of slaughterhouse waste (SHW).
- All systems having a minimum of two primary bins or equivalent.
- All primary bins using a minimum of 1 foot of base material and a biofilter cover of 1 to 2 feet.

Based on the guidelines for C/N ratio and biofilter cover as outlined in chapters 1 and 2, Keener et al. (1999) analyzed mixing ratios and specific amendment volumes for poultry, swine and cattle. Equations were developed for primary stage time and volume, secondary stage time and volume, and storage time and volume. An evaluation of composting meat processing by-products in static piles provided additional insight into procedures for composting SHW (Keener and Elwell, 2002).

Equations for primary, secondary and storage stage time and volume

The primary stage time **(T_1)** is estimated using the body weight **(W_1)** of the largest animal. Estimated primary stage times for animals of different weights are listed in Table 3-1. Individuals planning to compost should note that the **minimum time in the primary stage of composting is 10 days** to ensure that temperatures are greater than 131ºF for a period of three consecutive days. At temperatures above 131ºF, research has shown that most pathogens, insects and weed seeds die due to heat exposure. In addition, under optimal composting conditions the time lengths shown may be considerably shorter. To evaluate the decomposition process, use a long stem thermometer 2-3 times per week to monitor and chart pile temperatures more accurately. Equation 1 can be used to estimate the primary stage time:

Primary Stage Time (T_1, in days) = 5 x $\sqrt{W_1}$, Minimum time: 10 days (EQ 1)

Table 3-1. Primary stage time (T_1, days) for typical animal body sizes.

Body size (**W_1, lbs**)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Primary Stage Time (**T_1, days**)	10	11	16	30	35	50	61	74	87	94	112	158	194

Source: *Adapted from USDA-NRCS, Livestock Mortality Composting Manual, Operations & Maintenance Plan, 210-AWMFH, Chapter 13, OH-8, 3/00, pg 1*

The Average Daily Loss **(ADL)** is an estimate of the total weight of mortality produced per year divided by days in the year (365). ADL is calculated using mortality rates, animal numbers, and batches or groups of animals that are contained within a production unit on a yearly basis. For livestock production systems that experience frequent or daily mortality (swine and poultry), the ADL calculation is a very accurate estimate of rate of additions to the compost pile. For those systems where mortality occurrences are less frequent or seasonal (beef, sheep, goats, horses), an alternative to the ADL calculation is more appropriate and design parameters are adjusted to compensate for changes in timing and volume or area needed to effectively complete the compost process.

Table 3-2 provides typical livestock mortality rates and design weight criteria that are used to determine the area of the compost facility. However, actual death loss data from the operation will provide the most accurate estimate of total morality, daily mortality, and the largest animal projected to be added to the compost facility. Worksheets for calculating general livestock, swine, and poultry death loss are in Appendix A (NRCS OH-ENG-233a; NRCS OH-ENG-233s; NRCS OH-ENG-233p).

Table 3-2. Livestock mortality rates for production systems and corresponding design.

Poultry[1]				
	Avg Wt[3] (pounds)	Loss rate (%)	Flock life	Design weight[4] W_1 (pounds)
Broiler (mature)	4–8	4.5–5	42–49 days	Up to 8
Layer	4.5	14	440 days	4.5
Broiler, breeding hen	4–8	10–12	440 days	8
Turkey, female (meat)	15–25	6–8	95–120 days	25
Turkey, male (meat)	25–42	12	112–140 days	35
Turkey, breeder replace.	15 (birth–30)	5–6	210 days	20
Turkey, breeding hen	28–30	5–6	180 days	30
Turkey, breeding tom	70–80	30	180 days	75

Swine[2]					
Growth stage	Average weight[3] (pounds)	Loss rate (%)			Design weight[4] W_1 (pounds)
		Excellent	Good	Poor	
Birth to weaning	6	<12	12	>12	10
Nursery	37	<2	2–4	>4	55
Wean to finishing	194	<2	2–4	>4	285
Breeding herd[5]	550	<11	11	E>11	550

Cattle/horses[6]					
Growth stage	Average weight[3] (pounds)	Loss rate (%)			Design weight[4] W_1 (pounds)
		Excellent	Good	Poor	
Birth	70 - 130	<8	8 - 10	>10	130
Weanling	600	<2	2 -3	>3	600
Yearling	900	<1	1	>1	900
Mature[5]	1400	<0.5	0.5 - 1	>1	1400

Sheep/goats[6]					
Growth stage	Average weight[3] (pounds)	Loss rate (%)			Design weight[4] W_1 (pounds)
		Excellent	Good	Poor	
Birth	8	<8	8 - 10	>10	10
Lambs	50-80	<4	4 - 6	>6	80
Mature[5]	170	<2	3 - 5	>8	170

[1]Adapted from Ohio Poultry Association Information; [2] Adapted from *Pork Industry Handbook* – 100; [3] Average weight used to calculate pounds of annual mortality; [4] Design weight used to calculate composting stage periods; [5]For mature animals the percent loss is an annual rate for the average number of head on the farm; [6] The design weight and mortality rates for cattle, horses, sheep and goats need to be verified with the producer, the table figures are estimates from OSU livestock specialists. The mortality rate for these species will not likely be constant throughout the year.

Source: *Adapted from USDA-NRCS, Livestock Mortality Rates and Design Weights, OH-ENG-mortality rate*

Primary Stage Volume

Determination of the **primary stage volume** requires a combination of the size of the largest animal and/or the ADL for the farm. The primary stage composter volume **(V_1, feet^3)** for systems with regular, predictable, and generally more consistent mortality occurrences (swine and poultry) is calculated from equation 2 where: V_1= Volume, ADL = Average Daily Loss, and T_1= Days (from EQ 1 or Table 3-1).

$$\mathbf{V_1 \geq 0.2 \times ADL \times T_1,\ ft^3} \qquad \text{(EQ 2)}$$

With large animals and infrequent deaths, equation 2 will sometimes underestimate the primary volume needed. Equation 2a is a modification of equation 2 that correctly calculates primary volume and is applicable for any animal size.

$$\mathbf{V_1 = 0.2 \times W_1 \times integer\ (ADL \times T_1 / W_1),\ ft^3} \qquad \text{(EQ 2a)}$$

Table 3-3 summarizes the primary stage volume calculations based on primary stage time (T_1) and average daily loss (ADL). For example, if the weight (W_1) of the largest animal is 100 lbs and the ADL 50 lbs, the primary stage volume (V_1) would need to be 50 ft^3. Producers must also understand that larger animals will require extra space because of longer legs and bodies that are required to be covered entirely in the compost pile

Table 3-3. Primary volume (feet^3) vs. body size and mortality rate

Design Wt. (W_1, lbs.)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Primary Stage (T_1, days)	10	11	16	30	35	50	61	74	87	94	112	158	194
ADL (lbs./day)	**Primary Stage Volume (V_1, ft^3)[a]**												
1	2	2	3	7	10	20	30	44	60	70	100	200	300
5	10	11	16	30	35	50	61	74	87	94	112	200	300
10	20	21	32	59	71	100	122	148	173	187	224	316	387
25	50	53	79	148	177	250	306	371	433	468	559	791	968
50	100	106	158	296	354	500	612	742	866	935	1118	1581	1936
75	150	159	237	444	530	750	919	1112	1299	1403	1677	2372	2905
100	200	212	316	592	707	1000	1225	1483	1732	1871	2236	3162	3873
150	300	318	474	887	1061	1500	1837	2225	2598	2806	3354	4743	5809
200	400	424	632	1183	1414	2000	2449	2966	3464	3742	4472	6325	7746
300	600	636	949	1775	2121	3000	3674	4450	5196	5612	6708	9487	11619
400	800	849	1265	2366	2828	4000	4899	5933	6928	7483	8944	12649	15492
750	1500	1591	2372	4437	5303	7500	9186	11124	12990	14031	16771	23717	29047
1000	2000	2121	3162	5916	7071	10000	12247	14832	17321	18708	22361	31623	38730
1500	3000	3182	4743	8874	10607	15000	18371	22249	25981	28062	33541	47434	58095

[a] Shaded area is minimum volume based on the size of the animal.

Source: *USDA-NRCS, Compost Volume Tables 1-3, OH-ENG-232, 3/00, Table 1, pg 1*

Secondary Stage Volume

Mortality composting research (Brodie and Carr, undated; Elwell et al., 1998) indicates that the secondary composting time does not need to be equivalent to the primary-stage time. Instead, it should be based on heating and cooling of the pile. Usually, this stage lasts from 10 to 30 days and is generally considered to be **one-third of the time required for the primary stage**. For design and operational purposes, an estimate of secondary stage time (**T_2**) and volume (**V_2**) are calculated using equations 3 and 4:

$$T_2 = \tfrac{1}{3} \times T1 \;\geq 10 \text{ days} \qquad \text{(EQ 3)}$$

$$V_2 \geq \; 0.2 \times ADL \times T_2, \text{ ft}^3 \qquad \text{(EQ 4)}$$

The use of a minimum of 10 days or one-third of the primary time (T_1) is based on approximating minimum times found in poultry mortality composting and the times of sustained re-heating in the secondary stage for larger animals. A modified version (equation 4a) for use with large animals or infrequent mortality cases is:

$$V_2 = 0.2 \times W_1 \times \text{Integer}\,(ADL \times T_2 / W_1), \text{ ft}^3 \qquad \text{(EQ 4a)}$$

The volume of the secondary stage bin or pile must be greater or equal to the primary bin size so that it can hold the compost generated from up to three primary bins. Ideally, all bins should generally be of equal size so that they match equipment needs and are flexible for use as primary, secondary, or storage areas. For windrow composting, size restrictions are related to desired overall pad dimensions necessary to handle the volume of mortality generated. Equation 4a most accurately measures windrow area. Table 3-4 summarizes the secondary stage volume calculations, combining time (T_2) and average daily loss (ADL).

Table 3-4. Secondary volume (ft^3) vs. body size and mortality rate

Design Wt. (W_1, lbs)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Secondary Stage (T_2, days)	10	10	10	10	12	17	20	25	29	31	37	53	65
ADL (lb/day)	Secondary Stage Volume (V_2, ft^3)[a]												
1	2	2	2	7	10	20	30	44	60	70	100	200	300
5	10	10	10	10	10	20	30	44	60	70	100	200	300
10	20	20	20	20	24	33	41	49	60	70	100	200	300
25	50	50	50	50	59	83	102	124	144	156	186	264	323
50	100	100	100	100	118	167	204	247	289	312	373	527	645
75	150	150	150	150	177	250	306	371	433	468	559	791	968
100	200	200	200	200	236	333	408	494	577	624	745	1054	1291
150	300	300	300	300	354	500	612	742	866	935	1118	1581	1936
200	400	400	400	400	471	667	816	989	1155	1247	1491	2108	2582
300	600	600	600	600	707	1000	1225	1483	1732	1871	2236	3162	3873
400	800	800	800	800	943	1333	1633	1978	2309	2494	2981	4216	5164
750	1500	1500	1500	1500	1768	2500	3062	3708	4330	4677	5590	7906	9682
1000	2000	2000	2000	2000	2357	3333	4082	4944	5774	6236	7454	10541	12910

1500	3000	3000	3000	3000	3536	5000	6124	7416	8660	9354	11180	15811	19365

[a] Shaded area is minimum volume based on the size of the animal.

Source: *USDA-NRCS, Compost Volume Tables 1-3, OH-ENG-232, 3/00, Table 2, pg 1*

Storage Stage Volume

Because land application may not be feasible at all times, storage space and estimated time **(T_3)** available need to be considered. A minimum of 30 days is recommended. Volume of storage **(V_3)** can be calculated using equation 6.

$$T_3 \geq 30 \text{ days} \qquad \text{(EQ 5)}$$

$$V_3 \geq 0.2 \times ADL \times T_3,\ ft^3 \qquad \text{(EQ 6)}$$

Equation 6a represents a modified version to estimate V_3 for large or infrequent mortality additions.

$$V_3 = 0.2 \times W_1 \times \text{Integer}\,(ADL \times T_3 / W_1),\ ft^3 \qquad \text{(EQ 6a)}$$

Volume for the storage bin must be greater or equal to the secondary bin size since it must hold all material emptied from a secondary bin. Equation 6a will avoid underestimating windrow size. Table 3-5 summarizes the storage volume based on the length of storage (T_3) and average daily mortality (ADL).

Table 3-5. Storage volume (ft^3) vs. body size and mortality rate

Design Wt. (W_1, lbs)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Storage Stage (T_3, days)	30	30	30	30	30	30	30	30	30	30	30	30	30
ADL (lb/day)	Storage Stage Volume (V_3, ft^3)[a]												
1	6	6	6										
5	30	30	30	30	30	30	30						
10	60	60	60	60	60	60	60	60	60				
25	150	150	150	150	150	150	150	150	150				
50	300	300	300	300	300	300	300	300	300		USE VALUES FROM TABLE 3-4		
75	450	450	450	450	450	450	450	450	450				
100	600	600	600	600	600	600	600	600	600				
150	900	900	900	900	900	900	900	900	900				
200	1200	1200	1200	1200	1200	1200	1200	1200	1200				
300	1800	1800	1800	1800	1800	1800	1800	1800	1800				
400	2400	2400	2400	2400	2400	2400	2400	2400	2400				
750	4500	4500	4500	4500	4500	4500	4500	4500	4500				
1000	6000	6000	6000	6000	6000	6000	6000	6000	6000				
1500	9000	9000	9000	9000	9000	9000	9000	9000	9000				

[a]Shaded area is minimum volume based on the size of the animal.

Source: *USDA-NRCS, Compost Volume Tables 1-3, OH-ENG-232, 3/00, Table 3, pg 2*

Mortality Composting Facility Design Guidelines

Table 3-6 summarizes the steps for sizing of a composting facility. As noted earlier, for large animals and low average daily loss (ADL), volumes needed for primary, secondary and storage should be calculated using equations 2a, 4a and 6a.

Table 3-6. Design procedures for animal mortality composting systems.

Step	Description
A	Determine the average daily weight of animal mortality: 1. Multiple livestock species can be composted together, unless a dangerously contagious or reportable disease is suspected (see disease list, chapter 5). Biosecurity measures must be considered for site selection and operation to prevent disease transmission. 2. Use farm records, including animal sizes, livestock production values and loss records, when possible; or calculate the livestock mortality rates using NRCS OH- ENG-233a, 233 swine or 233 poultry factsheets developed for various livestock species. 3. For swine facilities the following assumptions should be used if operator records are not available: • Each sow yields 2.5 litters of pigs per year • Each litter = 10 pigs • For finish operations, the number of hogs = 2.7 × finishing building capacity 4. The average daily death loss should be determined for each growth stage on the farm. 5. Pounds of mortality produced from operations in one year using “**average weight”**. Average daily loss (ADL) in pounds per day to be composted. For some livestock operations the mortality rate is not constant throughout the year. See form NRCS OH-
B	Determine composting stage times using the **design weight (W_1)** to be composted in a windrow or bin. Note: Primary stage time and volume increase with animal weight. For an operation with multiple growth stages, segregation of mortality into bins or windrows should be considered to enhance compost efficacy. Consider separate facilities for animals within weight ranges (< 50 lbs), (50 – 250 lbs), and (> 250 lbs). For animals exceeding 500 to 600 pounds, the windrow composting method may be preferred because individual primary bins would be large and the placement of animals would be difficult. For mature cattle or horses, a pile on a composting pad for the individual mortality is preferred. The following equations are described further in Examples 1 through 3. 1. Primary Stage Time (in days) = $5 \times \sqrt{W_1}$: Minimum time: 10 days 2. Secondary Stage Time (in days) = 1/3 Primary Stage Time: Minimum time: 10 days 3. Storage Time: 30 days (needs to be considered when land application is not feasible immediately following completion of secondary stage)
C	Determine composter volumes using NRCS OH-ENG-234a or 235a. The following equations are solved in Tables 3-5, 3-6, and 3-7. 1. Primary Stage Volume (ft^3) = 0.2 × Average Daily Loss (ADL, lbs/day) × Primary Stage Time (days) 2. Secondary Stage Volume = 0.2 x ADL (lbs./day) x Secondary Stage Time (days) 3. Storage Volume = 0.2 × ADL × 30 days *Note: For large animals use alternate equations in NRCS OH-ENG-234a or 235a*
D	Determine the dimensions of the compost facility, bin dimensions, and windrow size or number of bins using NRCS OH-ENG-234a or 235a. Note, in a bin system, the minimum front dimension (width) should be 2 feet greater than the loading bucket width. An alternative to building individual secondary bins is to establish a large area to accommodate more than one primary bin. This bin is generally directly behind the primary bins. Standard NRCS Drawing OH-N-506-CAD is an example of this configuration.

E	Determine the annual sawdust requirement for the composting system using NRCS OH-ENG- 234a or 235a. This calculation assumes all sawdust needs are met with fresh sawdust. In practice, it is recommended that up to 50 percent of the fresh sawdust needs be met with compost that has completed the secondary cycle.

Source: *USDA-NRCS, Design Procedure for Animal Mortality Composting Systems, OH-ENG-compost inst., 3/00*

Example Designs

Dimensions of windrows or bins are determined using **Tables 3-7 and 3-8** that provide step-by-step guides to determine the **size and number** of bins **OR** the **composting area** for a windrow system. Windrow system volume will be based on desired pile height. A 1:1 side ratio is necessary to adequately shed water in outdoor piles or windrows. Pad height determines pile or windrow width and overall compost pad area. If mortality body size and average daily mortality rates are known, **Tables 3-3, 3-4, and 3-5** can be used to directly determine the required composting stage times and windrow or bin volumes.

Table 3-7. Windrow volume calculations. Assumes a 1-ft top width and 1:1 ratio for side slopes.

Windrow height (feet)	**Windrow x-section area** (square ft per linear ft)	**Windrow base width** (feet)	**Pad width**[1] (feet)
5	30	11	52
6	42	13	56
7	56	15	60

[1]Assume 2 windrows per pad; 10 feet on each side and between piles. (i.e. 10 + 11 + 10 + 11 + 10 = 52 ft)

Table 3-8. Bin volume based on combination of width and length; NOTE: depth of bin composter = 5 ft

Width / length	**4**	**6**	**8**	**10**	**12**	**14**	**16**
	Bin volume (feet^3)						
4	80	120	160				
6	120	180	240	300	360		
8	160	240	320	400	480	560	640
10		300	400	500	600	700	800
12		360	480	600	720	840	960
14		420	560	700	840	980	1120
16		480	640	800	960	1120	1280

Worksheets to calculate volumes and determine the pad size for windrows or number of compost bins needed are provided in Appendix A (NRCS-OH-ENG-234a; NRCS-OH-ENG-235a). Completed compost system design examples are provided and described for poultry, swine, and cattle examples. The examples bring the information provided in chapter 3 together for hypothetical animal mortality systems.

Example 1—Poultry (mini-bin)

Given: Design weight (W_1) = 3 lbs
Average daily loss (ADL) is 30 lbs/day
Design: Bin composting system

Primary stage time (T_1) = 5 x $\sqrt{W_1}$ = 10 days
Secondary stage time (T_2) = 1/3 x T_1 = 10 days
Storage time (T_3) = 30 days

Primary volume (V_1) = 0.2 x ADL x T_1 =n60 ft^3
Secondary volume (V_2) = 0.2 x ADL x T_2 = 60 ft^3 (for 1 primary bin)
Storage volume (V_3) = 0.2 x ADL * T_3 = 180 ft^3
Sawdust requirements = lbs loss/yr x 0.0069 = (30 lbs/day x 365 days) x 0.0069 = 76 cu yds/yr

From Table 3.7 for bin depth = 5 ft, select a bin volume of 80 ft^3
The appropriate bin size is: 4 ft x 4 ft x 5 ft

Bin numbers are: 2 primary and 1 secondary bin, each 4 feet x 4 feet x 5 feet.
One storage area capable of holding > 180 ft^2 (30 days × 60 ft^3)
Note: Could be 3 additional bins or pile with adequate base area to hold volume. Storage pile can be >5ft depth but should not exceed 7ft.

Example 2- Swine wean to finish (bin)

Given – 1225 hogs/barn; 2 barns; 2 turns/yr (total of 4900 hogs/year)
Design weight (W_1) – 285 lb; Average weight – 194 lbs; Average loss rate – 3% (0.03)

Average Daily Loss (ADL) = (194 lbs/hog x 4900 hogs/yr x 0.03) ÷ 365 day/yr = 78 lbs/day

Primary stage time (T_1) = 5 * $\sqrt{W_1}$ = 84 days
Secondary stage time (T_2) = 1/3 * T_1 = 28 days
Storage time (T_3) = 30 days

Primary volume (V_1) = 0.2 x ADL x T_1 = 1310 cu ft
Secondary volume (V_2) = 0.2 x ADL x T_2 = 437 cu ft (for 1 primary bin)
Secondary volume assuming 3 primary bins combined = 1311 cu ft
Storage volume (V_3) = 0.2 x ADL * T_3 = 468 cu ft
Sawdust requirements = lbs loss/yr x 0.0069 = (194 lbs x 4900 hogs x 0.03) x 0.0069 = 197 cu yds/yr

Assumptions for bin size– 5-ft bin depth; 10-ft wide; 16-ft deep. Bin capacity – 800 cu ft

Number of primary bins = (V_1 ÷ bin capacity) + 1 bin = 3 primary bins
Other bins – 1 secondary bin; 1 compost storage bin; 1-2 sawdust storage bins

Example 3- Swine wean to finish (windrow)

Given – 1225 hogs/barn; 2 barns; 2 turns/yr (total of 4900 hogs/year)
Design weight (W_1) – 285 lb; Average weight – 194 lbs; Average loss rate – 3% (0.03)

Average Daily Loss (ADL) = (194 lbs/hog x 4900 hogs/yr x 0.03) ÷ 365 day/yr = 78 lbs/day

Primary stage time (T_1) = 5 * $\sqrt{W_1}$ = 84 days
Secondary stage time (T_2) = 1/3 * T_1 = 28 days
Storage time (T_3) = 30 days

Primary volume (V_1) = 0.2 x ADL x T_1 = 1310 cu ft
Secondary volume (V_2) = 0.2 x ADL x T_2 = 437 cu ft
Secondary volume assuming 3 primary bins combined = 1311 cu ft
Storage volume (V_3) = 0.2 x ADL * T_3 = 468 cu ft
Sawdust requirements = lbs loss/yr x 0.0069 = (194 lbs x 4900 hogs x 0.03) x 0.0069 = 197 cu yds/yr

Given: windrow height = 7 ft; 1;1 ratio for side slope; 2 windrows per pad
From table 3-6: Windrow area = 56 sq ft; Windrow base width = 15 ft

Primary windrow length = V_1 ÷ windrow base = 23 ft
Secondary windrow length = V_2 ÷ windrow base = 8 ft
Storage windrow length = V_3 ÷ windrow base = 8 ft

Pad length = longest of primary or (secondary + storage) + 5 ft each end = 23 ft + 10 ft = 33 ft
Pad width = base width windrow 1 + base width windrow 2 + 10 ft each side + 10 ft between
= 10 ft + 15 ft + 10 ft + 15 ft + 10 ft = 60 ft
Pad area = 33 ft x 60 ft = 1980 sq ft

Example 4—Cattle (windrow)

Given: Design weight (W_1) = 1,400 lbs
Average daily mortality (ADL) is 20 lbs/day

Primary stage time (T_1) = 5 * $\sqrt{W_1}$ = 187 days
Secondary stage time (T_2) = 1/3 * T_1 = 62 days
Storage time (T_3) = 30 days

NOTE: Use alternative volume equations 2a, 4a, and 6a, which are used for large animals. Round up calculation in parentheses to an integer and use that in the calculation (e.g., ADL x T_1/W_1 = 2.7 so is rounded to 3 for the calculation: V_1 = 0.2 x W_1 x 3) .

Primary volume (V_1) = 0.2 x W_1 x integer (ADL x T_1/W_1) = 840 ft^3
Secondary volume (V_2) = 0.2 x W_1 x integer (ADL x T_2/W_1) = 280 ft^3
Storage volume (V_3) = 0.2 x W_1 x integer (ADL x T_3/W_1) = 280 ft^3
Sawdust requirements = lbs loss/yr x 0.0069 = (20 lbs/day x 365 days) x 0.0069 = 50 cu yds/yr

Given: windrow height = 7 ft; 1;1 ratio for side slope; 2 windrows per pad
From table 3-6: Windrow area = 56 sq ft; Windrow base width = 15 ft

Primary windrow length = V_1 ÷ windrow base = 15 ft
Secondary windrow length = $V2_1$ ÷ windrow base = 5 ft
Storage windrow length = V_1 ÷ windrow base = 5 ft

Pad length = longest of primary or (secondary + storage) + 5 ft each end = 15 ft + 10 ft = 25 ft
Pad width = base width windrow 1 + base width windrow 2 + 10 ft each side + 10 ft between
= 10 ft + 15 ft + 10 ft + 15 ft + 10 ft = 6- ft.
Pad area = 25 ft x 60 ft = 1,500 ft^2

Slaughterhouse Waste Composting Design

The volume of waste produced is used to determine the volume of amendment needed. The ratio of amendment to slaughterhouse waste (SHW) should be about 6:1 (v/v). The volume of SHW is estimated using the bulk density (~60 lbs/cu ft), and then the amendment volume and bin size are determined. It is recommended that SHW be added daily, and that each Stage 1 bin be filled within 7-10 days for large volumes of SHW and up to 35 days for smaller volumes (<300 lbs or 5 cu ft). Figure 3-1 shows the recommended thicknesses of the layers in the Stage 1 bin. If less than 8 inches of SHW are added daily, it should be covered with 6-12 inches of sawdust until the next addition at which time 1/3 to 3/4 of the sawdust is scraped to the sides, the SHW added, and the sawdust layer replaced.

Sawdust – 12-24 in
Slaughterhouse waste[1] – 6-18 in
Sawdust or finished compost – 6 in
Slaughterhouse waste[1] – 6-18 in
Sawdust or finished compost – 12 in
Woodchips – 12 in

Figure 3-1. Material layers - Stage 1

[1] Place 6-12 in. of amendment along the perimeter of the bin for the SHW layer.

The size and number of bins needed is based on the total volume of material (amendment + SHW) for the Stage 1 bin and the time required for each stage. It is recommended that the bin height, including the top sawdust layer, be less than 6 feet. The number of bins needed for Stage 1 is 35 days **÷** number of days to fill the bin **+** 1. After 35 days, based on time of the last addition, the materials are mixed and moved to the Stage 2 bin, where they remain for 35 days before being mixed and moved to the Stage 3 bin. For Stages 2 and 3, the number of bins required is one less than the number of Stage 1 bins. A concrete or impervious floor can reduce the risk of leachate seeping into subsurface water.

<u>Example 1. Design for large volume SHW composting system</u>:
If 4,000 lbs of SHW are produced weekly and the working depth of a bin is ~6 feet, then:

1) **Volume of SHW** = 4,000 lbs ÷ 60 cu ft/lbs = **~70 cu ft**
2) **Volume of amendment** = 70 cu ft x 6 = **420 cu ft**
3) **Total volume** = 70 cu ft + 420 cu ft = **590 cu ft**
4) **Area of Stage 1 bin** = 590 ÷ 6 ft = **~100 sq ft** (bin dimension of 10 ft x 10 ft x 6 ft)
5) **Number of bins for Stage 1** = 35 days ÷ 7 days to fill + 1 = **6 bins**
6) **Number of bins for Stage 2 and 3** = 6 - 1 = **5 bins** for each stage

Figure 3-2 shows a recommended layout for this system. Note that a combined bin of 10 ft x 50 ft is used for Stage 2, with another one for Stage 3. Two additional bins (10 ft x 10 ft x 10 ft) are used to store amendment and finished compost.

<table>
<tr><td>Stage 1
(week 1)</td><td>Stage 1
(week 2)</td><td>Stage 1
(week 3)</td><td>Stage 1
(week 4)</td><td colspan="2">Stage 2
(fill direction →)</td></tr>
<tr><td colspan="6">Aisle for equipment movement
(10 ft wide)</td></tr>
<tr><td>Storage
(amend)</td><td>Stage 1
(week 5)</td><td>Stage 1
(week 6)</td><td colspan="2">Stage 3
(fill direction →)</td><td>Storage
(comp)</td></tr>
</table>

Figure 3-2. Floor plan for composting 4,000 lbs SWH per week (90 ft x 30 ft)

Example 2. Design for small volume SHW composting system:
For small volumes of SHW (<300 lbs or 5 cu ft), bin size is typically based on available materials (e.g., 4 ft x 8 ft plywood), with the final amendment layer being up to 12 in above the top of the bin. Because the SHW is typically added over several weeks, an amendment to SHW ratio of 5:1 (v/v) and a thinner base layer (18 in) may be used.

If 175 lbs of SHW are produced weekly, then:

1) **Volume of SHW** = 175 lbs ÷ 60 cu ft/lbs = **~3 cu ft**
2) **Volume of amendment** = 3 cu ft x 5 = **18 cu ft**
3) **Total volume** (7 days) = 3 cu ft + 18 cu ft = **21 cu ft**

It is not practical to build a bin for such a small volume of materials, so longer addition times were evaluated. It was found that 35 days provides a practical solution:

4) **Volume of SHW** (35 days) = 3 cu ft x 5 weeks = **15 cu ft**
5) **Volume of amendment** (35 days) = 15 cu ft * 5 = **75 cu ft**
6) **Total volume** (35 days) = 15 cu ft + 75 cu ft = **90 cu ft**
7) **Area of Stage 1 bin** = 90 cu ft ÷ 5 ft = **~18 sq ft** (bin dimension: 4 ft x 4 ft x 5 ft)
8) **Number of bins for Stage 1** = 35 days ÷ 35 days to fill + 1 = **2 bins**
9) **Number of bins for Stage 2 and 3** = 2 – 1 = **1 bin** for each stage

Figure 3-3 shows a recommended layout for this system. The management of the system would be as follows:

- **Week 1**: Base layer of 9 in of woodchips topped by 9 in of amendment; layer of SHW (~4 in) with 6 in amendment between the SHW and bin sides; top layer of amendment (12 in).
- **Week 2**: Remove top 6 in of amendment. Add layer of SHW (~4 in) with 6 in amendment between the SHW and bin sides; replace top layer of amendment (12 in).
- **Weeks 3-5**: Repeat steps in week 2. The 35 days recommended for Stage 1 begins after the last addition.
- **Week 10**: Mix and move all materials to Stage 2 bin.

Storage (sawdust)	**Stage 1** (weeks 1-5)	**Stage 1** (weeks 6-10)	**Stage 2** (35 days)	**Stage 3** (35 days)	**Storage** (compost)

Figure 3-3. Floor plan for composting 175 lbs SWH per week (24 ft x 4 ft).

CHAPTER 4

Management of the Compost Facility and Compost Utilization

Michael J. Monnin, PE, NRCS

Chapter 3 described the sizing of the facility for composting animal mortalities and slaughterhouse waste in Ohio. This chapter presents the procedures to follow in managing the composting facility operations, either bin or windrow systems.

Compost process: Composting is a controlled natural process in which beneficial microorganisms reduce and transform organic wastes into a useful product (compost). It is a predominately aerobic process that does not produce offensive odors but does produce a final product that is safe and can be used as a crop fertilizer or soil amendment.

Mortality composting

- The mortality composting method utilizes sawdust or other acceptable materials as the carbon amendment.
- The animal mortality supplies the necessary nitrogen and some moisture for the composting process to take place.
- The volume of the carcass and pile mass will be reduced 25–30% on completion.
- The **primary stage reduces the mortality** to where only larger bones remain.
- The **secondary stage completes the decomposition** of the mortality.
- The **storage stage stabilizes** the compost and allows for optimal land application.

Primary stage management

- Place a minimum 1 foot of sawdust or absorbent hay, straw, or other amendment on the floor/base.
    - Animals should not be placed directly on soil, gravel, or concrete floors because they will *not* compost properly and will not meet composting requirements.
    - Larger animals (> 400 lbs) will require additional base material (2 feet or greater depth).
- Place 1 layer of livestock mortality on the base and cover mortality as follows:
    - In bins use a minimum of 1 foot of amendment to cover
    - In windrows or piles use a minimum of 2 feet of amendment to cover.
- Place no animals closer than 1–2 feet from the sides of the bin to allow air transfer.
- The cover amendment helps eliminate scavenging animals and minimize odors.
    - Most problems arise when insufficient amendment is covering the mortality.
- Windrows and piles must be shaped and rounded to resist rain and weather.
    - Re-mound and reshape windrows and piles as needed.
    - Do not allow pockets to form and eliminate areas that will trap water.

Adding or loading primary stages

- Hollow-out a cavity in the existing compost.
- Place the mortality one animal thick and re-cover with a minimum of 1 foot of

sawdust for bins and 2 feet for windrows or piles.
- If finished compost is available, it should be used as the initial cover over the carcasses.
  - Maintain fresh amendment on the outside of the pile or bin.
- Use a pointed dowel or rod to measure the thickness of the sawdust cover.
- Do not put animals on top of animals, Maintain 1/2-1 foot between animals.
- Avoid adding frozen carcasses if possible.
  - If frozen carcasses are loaded, add additional time to the primary stage.
- Monitor progress with a compost thermometer to chart temperature progression and decline.

Monitoring primary stage decomposition
- Monitor compost temperature with a long-stem, dial-type thermometer.
- Proper composting will allow temperatures to reach 130–160 °F.
  - Pathogen kill, insect reduction, and weed seed germination are reduced with 3 consecutive days of >130 °F.
  - Temperatures of <100 °F for more than 1 week indicate either a problem with compost conditions or that the primary stage of composting has been completed.
- Bins, piles, or windrows started during cold weather may not begin composting immediately.
  - Compost temperature will increase as external temperatures increase.
- Active compost piles or bins will work throughout the winter cold.
- In cold weather, active piles will generally not have snow cover present.

Secondary stage management
- When temperatures remain <100 ºF for more than 1 week, the primary stage will likely need to be turned to allow completion of decomposition (initiation of secondary stage).
- Lifting, turning and/or mixing the primary stage will re-introduce air, expose remaining materials to bacteria, and allow finalization of the compost process.
- After turning, if bones or other materials are present on the surface, place a fresh layer of amendment over the mixed compost.
- Check the rigidity of any long bones or skulls observed when turning the pile.
  - Very hard bones should be sorted and put into an active primary stage.
- After turning, the pile will reheat and complete the decomposition process.
- Following completion of the designated secondary stage time or when temperatures decline to ambient temperature, the compost will be ready for movement to storage.

Storage
- Storage may initiate another heating cycle.
- Allow 30 days of storage space to allow for field application flexibility.
- Storage material may be mixed into primary stages at a rate of up to 50% by volume.

Utilization

- Finished compost can be recycled at **up to 50%** by volume of total needs when starting a new bin or pile.
  - Do not use >50% recycled material.
- Test finished compost for nutrient content.
- Apply finished compost to crop land or pasture at acceptable agronomic rates.

Sawdust management

- Keep sawdust relatively dry (40–50% moisture is recommended).
- Collect, store, and treat all leachate and runoff.

Other Notes

- During dry periods the surface of the windrow can become too dry and wind can blow sawdust off the pile leading to exposed animals and odor concerns.
- If carbon amendments such as corn stover or chopped straw are used, moisture loss will be more prevalent than with sawdust.
- Maintain access to a supplemental water source.

Windrow and pile-area management

- Keep the area around the compost unit mowed and free of tall weeds and brush.
- Fence the perimeter of windrow and pile composting systems.
- Monitor and control leachate.
- Monitor and control scavenging animals, including birds.

Nutrient utilization

- Finished compost should be applied to supply N, P_20_5 and K_20 requirements of agricultural crops following a farm-level Comprehensive Nutrient Management Plan.
- In the absence of a laboratory analysis, the nutrient content of the compost is estimated to be: Total nitrogen - 20 lbs./ton; Ammonia nitrogen - 4 lbs./ton; Phosphorus - 2 lbs./ton; Potassium - 6 lbs./ton.

Record keeping (*Required for CAFO designation, highly recommended for ALL operations)*

- Maintain daily records of compost additions.
- Maintain 2X or 3X weekly records of temperature for each stage in the facility.

Maintaining the pile base

- Maintain a *dry*, well-drained, solid base for the compost unit.
- Allows all-weather access for daily loading.

Pest management

- Scavenging animals can be a problem in bins and outdoor systems.
- Maintaining the necessary minimum cover (1 foot of sawdust for bins and 2 feet for windrows or piles) over all dead animals is the most important deterrent.
- Perimeter fencing is highly recommended.
- Never allow animal parts or bones to be exposed.

Maintenance

- Inspect compost unit when empty.
- Replace any broken or badly worn parts or hardware.
- Patch concrete floors, curbs, or gravel areas as necessary.
- Examine roofed structures for structural integrity and leaks.

Landscape Maintenance

- Keep all trees, shrubs, and flowers healthy in order to maintain a positive rural image.

Additional considerations for poultry mortality composting

1. The process uses a simple mixture of poultry manure, poultry carcasses, straw, and water (table 4-1). This will satisfy the requirements of readily available bacteria and fungi to convert these materials into inoffensive and useful compost. The volume of the mass will be reduced 25–30% in the process.

Table 4-1. Recipe of material proportions for poultry composting

Material	Parts by weight
Poultry carcasses	1.0
Poultry litter	1.2
Straw	0.1
Water	0.75

2. Once the weight of a day's poultry carcasses is determined, the other elements can be weighed out according to the recipe. The materials should be weighed in buckets on scales for the first few batches. For subsequent batches, a loader can be used once the weight of a full loader bucket has been determined for each material, except water. A hose can be used to deliver the correct amount of water based on the time necessary to deliver the required weight of water through the hose. The moisture content must be maintained between 40% and 60%, equivalent to that of a damp sponge. This is an important part of the composting process because a mixture that is too wet can become anaerobic and cause severe odor problems. Additional water may not be needed if sufficient moisture is available from other recipe ingredients.

3. For primary composting, the material is placed in the bins in layers in the following sequence (Figure 4-1):

a. One foot of dry poultry manure/litter should be placed on the concrete floor to absorb the excess moisture that is added. This manure weight is not part of the recipe.

b. A 6-inch layer of loose straw is placed on top of the manure layer to allow aeration under the carcasses.

c. A layer of carcasses is placed on the straw. Be sure to maintain 6 inches from the edge of the compost pile to the edge of the dead carcasses, so the carcasses are not exposed.

d. If needed, water is added according to the recipe.

e. A layer of manure/ litter, as per the recipe, is placed over the carcasses. The manure/litter must completely cover the chickens. This completes the first batch.

f. The second and each subsequent batch continue by repeating steps **b through e** above until the bin is full.

4. Temperature should be monitored daily using a 36-inch, probe-type thermometer with a rigid protective covering. Temperatures should peak at 130–140 °F after 5–7 days of composting. If temperatures of 130 °F are not achieved during the composting process, the resulting compost should be incorporated immediately after land application. If temperatures exceed 160 °F, the compost should be removed from the composting bin, spread on the ground to a depth not to exceed 6 inches in an area away from buildings, and saturated with water to prevent spontaneous combustion.

5. Primary composters can be unloaded as peak temperatures decline below 110 °F after a minimum of 10 days. Unloading the primary composter and loading the secondary composter should be done in a manner that assures maximum mixing of the composting material.

6. Moisture and temperature requirements, discussed in steps 3 and 5 above, also apply to the secondary stage. The compost removed from the secondary stage bin should be stored for 30 days before land application. The storage depth should not exceed 7 feet to reduce the potential for spontaneous combustion. In addition, it should not come in contact with any manure stored in the same facility. Storage will allow the compost to dry allowing greater ease in handling.

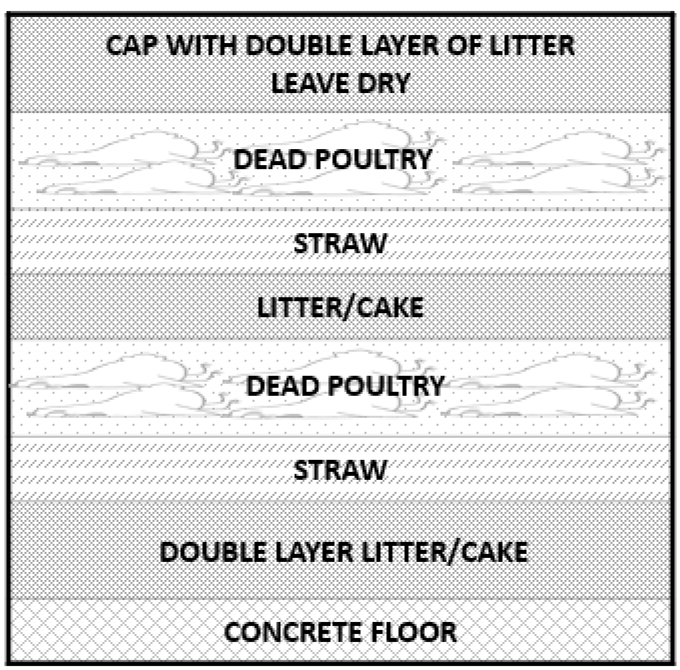


Figure 4-1. Poultry composting involves alternating layers of litter, straw and poultry mortality

7. Compost shall be land applied to supply N, P_20_5 and K_20 requirements. The nutrient requirements for a particular crop should be based on a current soil test. Compost application rates should be calculated on its nutrient content and applied following a nutrient management plan. Laboratory analyses should be completed regularly in the absence of a laboratory analysis, the nutrient content of the poultry compost is estimated to be:

Total nitrogen- 40 lbs/ton; Organic nitrogen-28 lbs/ton; Phosphorus- 20 lbs/ton; Potassium -25 lbs/ton

8. Inspect compost structure at least twice annually when the structure is empty. Replace any broken or badly worn parts or hardware. Patch concrete floors and curbs as necessary to assure water-tightness. Examine roof structures for structural integrity and leaks.

9. As discussed in item 3, maintaining the moisture content between 40 and 60 percent is vitally important. The primary and secondary composters and the storage or "resting" area should be protected from outside sources of water such as rain or surface runoff.

10. To properly manage the composting facility, daily records should be kept, particularly during the first several compost batches. This can be helpful in identifying problems that may occur. It is suggested to record daily the amount of sawdust added, the weight of the mortalities, and the temperature of the composting mix. Daily records may be kept on the attached *Composting record worksheet.* Off-farm facilities should ensure that the recordkeeping forms required by Ohio EPA are used.

11. Occasionally, compost materials will not heat up or will produce odors or seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for bacterial metabolism. Common mistakes are failure to provide all the materials needed for nutrient balance or aeration or sloppy loading of primary boxes so that materials are not "sandwiched." Too little straw (or alternate carbon source) results in a dense, anaerobic mass and one in which energy (from cellulose) is limiting. Too much water is a common problem. Saturated compost piles are anaerobic and will not support the desired aerobic, thermophilic metabolism needed for rapid, odorless digestion of carcasses. If the mixture is too wet or too dry, the decomposition rate is greatly reduced. Too wet, too dry, improperly mixed, or incomplete mixes of compost materials can be amended. When primary compost is turned, dry manure or straw may be added to a too wet compost, water can be added to a "dusty-dry" compost, and improperly mixed materials can be remixed. A little experience and perseverance usually give good results in a short time.

Chapter 5

Biosecurity and Disease Suppression

Dr. Sheila D. Grimes, Ohio Department of Agriculture
Dr. William Shulaw, The Ohio State University

What is bio security?
"Bio" means life and "security" implies some sort of protection. Thus, biosecurity implies the protection of life. In its simplest meaning, it means keeping germs (infectious disease agents) away from animals and keeping animals away from germs. A biosecurity program is a very important part of any animal and poultry health management program.

Why is biosecurity important?
Whenever we deal with a large number of animals, or birds, in a confined area, biosecurity is important. If a disease outbreak occurs, it could spread rapidly throughout the population. A disease outbreak could result in increased morbidity (sickness) or mortality (death loss) and be economically devastating for the producer. Therefore, a biosecurity program is a top priority in maintaining animal health.

What types of infectious agents cause disease and how are they transmitted?
Many types of infectious agents can cause disease including the following:

- Bacteria and bacterial spores (the hardy resting phase of some bacteria such as the one that causes tetanus)
- Viruses
- Fungi (including the resistant reproductive forms called "spores")
- Parasites (lice, mites, and worms)
- Protozoa (such as coccidia)
- Unconventional agents (such as "prions" which cause scrapie and bovine spongiform encephalopathy)

There are many ways in which infectious agents can be spread. They include:

- Aerosols (i.e. through the air)
- People (clothing, boots, shoes)
- Equipment (cleaning, manure handling, vehicles, grooming equipment, livestock trailers, etc.)
- Other animals (rodents, pets, wild birds, insects, carrier animals of the same species, etc.)

What are some biosecurity measures?
Biosecurity measures used on farms include:

- Rodent control inside and outside of buildings

- Wildlife control (such as bird-proofing buildings)
- Insect control (lice, flies, beetles, roaches etc.)
- Proper disposal of livestock mortalities
- Disinfection of equipment and vehicles
- Cleaning and disinfection of facilities after animals are removed
- Restricting people entry and access
- Isolation of new animals and quarantine of sick animals

How does composting destroy disease-causing organisms?
All disease-causing organisms are subjected to at least three adverse conditions during composting: heat, toxicity caused by products of decomposition, and microbial antagonism. Heat generated in the composting process is the primary determinant studied as the inactivator of disease-causing organisms. An extended period of heat in the desired range achieved during composting is essential for the destruction of most pathogens. The effect of pH and the action of other bacteria and fungi on the destruction of disease-causing organisms is still largely unknown.

Will composting destroy all disease-causing organisms?
No. Only minimal research has been done with disease-causing organisms of animals with regard to the ability of the composting process to destroy them. A recent review of chemical and microbial hazards to humans from urban waste composting facilities indicates that the assumption that all disease-causing organisms are killed by composting may be faulty.

Generally speaking, viruses are more heat sensitive than bacteria or fungi. Most viruses are typically inactivated at 50-60 °C (122 to 140 °F). Viral surface proteins are inactivated at 50-60 °C. rendering the viral particles noninfectious, since they are no longer capable of cellular attachment and uncoating. Most viruses, therefore, would not pose a significant problem with composting, because most compost piles obtain an internal temperature of 60 °C. However, certain viruses, such as the Foot and Mouth Disease virus, can withstand a temperature of 95 °C (203 °F) for 15 seconds.

The majority of vegetative bacteria are readily inactivated at 100 °C (212 °F or boiling). Bacteria have been classified into several categories based on their heat sensitivities. Some bacteria, called thermophiles, grow well at elevated temperatures of 60 °C. or greater. Such bacteria are useful in the decay of organic material in compost piles. However, other bacteria, called mesophiles and psychrophiles, are relatively heat sensitive, and have reduced or limited growth at 60 °C. The temperature limit for growth of mesophilic and psychrophillic bacteria is less than 50 °C; therefore, composting would probably inhibit growth for these categories of bacteria. Bacteria which are inactivated at 60 °C include *Bacillus anthracis*, the cause of anthrax, and *Mycobacterium tuberculosis*, which causes tuberculosis. Vegetative forms of the bacterium *Bacillus anthracis* are inactivated at 60 °C, but **NOT** anthrax spores. Other bacteria, such as clostridia, including *C. chauveoi, C. novyi* and *C. tetani*, are particularly resistant to heat inactivation. Some clostridia can survive boiling for two or more hours.

To our knowledge, data regarding the susceptibility of prions and bacterial and fungal spores to inactivation by composting are not currently available. However, in general, the literature indicates that a temperature of 121 °C (250 °F) for 15 minutes is essential for the inactivation of bacterial spores. The most common spore forming bacteria on Ohio farms belong to the genus clostridia and cause tetanus, enterotoxemia, blackleg, and malignant edema. Infectious agents referred to as prions are extremely resistant to heat inactivation as well as other forms of disinfection and sterilization. For the inactivation of prions, autoclaving (moist heat and a pressurized container) at 121 °C for 5 hours is recommended. Transmissible spongiform encephalopathies are prion-associated diseases. Composting temperatures typically range between 50-65 °C and therefore, would be ineffective in the heat inactivation of prions and bacterial spores.

Will composting increase the chances of disease or disease spread on my farm?
In general, composting should not increase the risk of disease or disease spread if the process and pile are properly managed. Some important procedures to minimize risk include the following.

- Locate the compost pile in a site that minimizes potential contact between animals and the pile.
- Manage the site to prevent contaminated runoff or leachate from contacting animal housing or vehicles and equipment. Disease-causing organisms may survive in contaminated leachate for at least several days and possibly a long period of time.
- Prevent rodents and scavenging animals from digging in the pile and spreading contaminated material.
- Following recommendations for sawdust covering will provide a barrier to most pests.
- Fencing may be necessary if proper coverage is not maintained and animals have gained access.
- Fly infestation problems are eliminated with appropriate pile temperature and sawdust cover on livestock mortalities.

Are there situations in which I would not be allowed to compost animal mortality?
In order to compost animal mortality other than the species already provided for (poultry, swine, cattle, sheep, goats and horses), approval by the Ohio Department of Agriculture, the Ohio Environmental Protection Agency, and the Ohio Department of Health is required. Special regulations may apply to some approved species such as cattle and sheep. Because of the special concerns of the transmissible spongiform encephalopathies and their resistance to destruction, sheep with scrapie and cattle over two-years-of-age showing signs of neurologic disease will not be permitted to be composted unless authorized by the Chief of the Division of Animal Industry.

The following are designated as dangerously contagious or reportable diseases in the State of Ohio (Ohio Revised Code 941.03 and Administrative Rule 901:1-21-02):

1. Anthrax
2. Ovine and caprine bluetongue
3. Brucellosis (*Brucella abortus, B. melitensis, B. suis*)

4. Newcastle Disease
5. Foot and mouth disease
6. Hog cholera
7. Psoroptic cattle scabies
8. Psoroptic sheep scabies
9. Vesicular exanthema
10. Venezuelan equine encephalomyelitis
11. Fowl typhoid
12. Highly pathogenic avian influenza
13. Pullorum (*Salmonella pullorum*)
14. Tuberculosis (*Mycobacterium bovis*)
15. Pseudorabies (Aujesky's disease)
16. Equine infectious anemia
17. Contagious equine metritis
18. *Mycoplasma gallisepticum* in turkeys
19. Scrapie
20. Rabies
21. Eastern equine encephalomyelitis
22. Poultry chlamydiosis-ornithosis
23. Poultry paramyxovirus (other than Newcastle disease)
24. Infectious encephalomyelitis (poultry)
25. Infectious laryngotracheitis (other than vaccine-induced)

Under most circumstances, premises upon which these diseases are found are placed under quarantine, and the disposition of animal mortality will be under the guidance and direct supervision of the Ohio Department of Agriculture. Decisions concerning the suitability of composting for disposal of mortality rest with that Department. In addition, the federal government maintains a list of foreign animal diseases, and authority for composting animal mortality caused by these diseases rests with the federal government and cooperating state governments.

CHAPTER 6

Laws and Regulations

Tammie Brown, Ohio Department of Natural Resources
Ángel Arroyo-Rodríguez, Ohio Environmental Protection Agency (2022 Revision)

The implementation and enforcement of Ohio's laws and regulations for animal mortality and slaughterhouse waste (also referred to as raw rendering material) is conducted by programs at the Ohio Department of Agriculture (ODA) and the Ohio Environmental Protection Agency (Ohio EPA) with the assistance of The Ohio State University (OSU) Extension, the OSU Ohio Agricultural Research and Development Center (OARDC), and the USDA-Natural Resources Conservation Service (NRCS). All these agencies and educational institutions share responsibility for regulating and providing technical and educational assistance to ensure responsible composting of animal mortalities and slaughterhouse waste. Below is a summary table of each agency's and institution's role followed by a brief explanation on applicable laws and rules.

Agency/Institution	Responsibilities
Ohio Department of Agriculture	
Division of Animal Health	Determines appropriate methods of disposal.
Division of Soil and Water Conservation (DSWC)	Permitting and compliance monitoring of on-farm composting.
Ohio Environmental Protection Agency (Ohio EPA)	
Division of Materials and Waste Management	Permitting and compliance monitoring of off-farm composting. Establishes compost product quality standards for both on-farm and off-farm.
The Ohio State University	
Ohio State University Extension	Provides animal mortality and slaughterhouse waste composting training certification.
Ohio Agricultural Research and Development Center (OARDC)	Research and development of standards for regulations and training.
US Department of Agriculture	
Natural Resources Conservation Service (NRCS)	Develops technical standards for on-farm composting of animal mortalities.

ODA, Division of Animal Health

ODA, through its Division of Animal Health, is charged with implementing the laws governing the control of animal diseases established in Chapter 941 of the Ohio Revised Code (ORC). The laws apply to both domestic (e.g., livestock and poultry) and non-domestic animals (e.g., wildlife and exotics). ORC Section 941.14 specifies the methods allowed for disposal of animal mortalities resulting from diseases. Accordingly, animal mortalities may be burned, buried (at least four ft. deep), dissolved through alkaline hydrolysis, delivered in a watertight tank to a rendering establishment, or composted in accordance with the regulations implemented by ODA-Division of Soil and Water Conservation (ORC Chapter 939) or Ohio EPA [Ohio Administrative Code (OAC) Chapter 560]. If ODA determines that the animals died due to a dangerously infectious disease the ODA Director may require a specific method of disposal.

The Division of Animal Health also implements the rendering laws specified in ORC Chapter 953, which govern the disposal of slaughterhouse waste. In accordance with ORC Section 953.22, a farmer that composts slaughterhouse waste on-farm following the on-farm composting requirements (ORC Chapter 939) is exempted from obtaining a rendering license. Slaughterhouse waste can also be composting at off-farm facilities regulated by Ohio EPA (OAC Chapter 560). However, delivery of the waste can only be performed by a transporter with a rendering license.

ODA, Division of Soil and Water Conservation

The Division of Soil and Water Conservation (DSWC) regulates on-farm animal mortality and slaughterhouse waste composting through under ORC Chapter 939 and OAC 901:13-1 (animal waste pollution abatement rules). DSWC rules apply exclusively to the operations described below.

1. The composting is conducted by the person who raises the animals and the compost product is used in agricultural operations owned or operated by that person, regardless of whether the person owns the animals (*in essence, farmers compost their livestock mortality on their own farm and reapplies it to their own fields)*; or
2. The composting is conducted by the person who owns the animals, but does not raise them and the compost product is used in agricultural operations either by a person who raises the animals or by a person who raises grain that is used to feed them and that is supplied by the owner of the animals *(the same general principle as above applied to contract/cooperative farming operations)*.

In order to compost, these operations are required to do the following:

1. Participate in an educational course concerning composting conducted by Ohio State University Extension and obtain a certificate of course completion, and
2. Use the appropriate method, technique, or practice of composting as established in the "USDA-NRCS Field Office Technical Guide" *(Standard 317 Composting Facility Standard)* or other such standard as approved by DSWC.

This rule is intended to prevent water pollution by livestock mortality composting. It does not address "nuisance issues" such as odors, dust, noise, or flies. It is enforced by ODA working through county SWCDs on a complaint basis as are all the Agricultural Pollution Abatement Rules.

ODA, Division of Livestock Environmental Permitting

The Division Livestock Environmental Permitting approves livestock waste management plans and issues permits to install for livestock operations exceeding 1,000 animal units. The composting of animal mortalities can be used as waste management strategy. The scope of this regulation is to prevent water pollution by manure and wastewater management. Applicants are required to indicate their plan for livestock mortality disposal in the livestock waste management plan.

Ohio EPA, Division of Materials and Waste Management
The Division of Materials and Waste Management has regulatory authority (through ORC Section 3734.02) over any composting of animal mortalities and slaughterhouse waste off farm. OAC Chapter 3745-560 establishes the requirements for composting these waste materials off-farm. Accordingly, individuals who compost these waste materials must do all the following:

1. Submit to Ohio EPA a registration application as a class II or class III composting facility.
2. Participate in an educational course concerning composting conducted by Ohio State University Extension and obtain a certificate of course completion.
3. Request an inspection from Ohio EPA to verify the facility is appropriately prepared.
4. Follow the operational requirements.
5. Meet the compost quality standards requirements developed by Ohio EPA, as mandated by ORC Section 3734.028.

In addition, ORC Section 3734.029 mandates that any owner or operator that composts dead animals and slaughterhouse waste on-farm under ORC Chapter 939 and that sells or offers for sale at retail or wholesale outlets, distributes for use, or gives away any compost, must also comply with the compost quality standards developed by Ohio EPA.

Ohio State University Extension (OSUE)
The Ohio State University Extension provides and conducts the Animal Mortality and Slaughterhouse Waste Composting Certification Training. This training is required by law to compost on-farm and off-farm.

Ohio Agricultural Research and Development Center (OARDC)
The OARDC's Compost Research Facility at the Wooster Campus conducted research and provided leadership in the development of animal mortality and slaughterhouse waste composting standards used to develop this training program and state regulations.

USDA-Natural Resources Conservation Service
The Natural Resources Conservation Service develops and maintains technical conservation practice standards, including livestock mortality composting. On-farm composting of livestock must follow this standard by law. The standard is covered in this manual and courses taught from it.

Nuisance Complaints
Odors, flies, noise, and dust are considered "nuisance" complaints. Properly managed, by maintaining adequate sawdust cover (1 ft. for bins, 2 ft. for windrows or piles), mortality compost units across the state have operated successfully without nuisance concerns. However, given the potential for nuisance complaints, it is a good idea to be familiar with the two Ohio statutes that cover them:

- ORC 929.04, commonly known as “The Farmland Preservation Act” governs civil suits between neighbors. In a civil action for nuisances involving agricultural activities, the law can be used as a defense if the farm is operating in an “agricultural district” (registered with the county auditor), the farm was in operation first, the person complaining is not a farmer, the activities do not conflict with any other rules, and reflect generally accepted agricultural practices.
- ORC 3767.13 is a statute enforced by the county health departments or Ohio Environmental Protection Agency. Section D that states: “persons who are engaged in agriculture-related activities and who are conducting those activities outside a municipal corporation, in accordance with generally accepted agricultural practices, and in such manner so as not to have a substantial, adverse effect on the public health, safety, or welfare are exempt from ... public or ordinances, resolutions, rules, and other enactments of a state agency or political subdivision that prohibit excessive noise or noxious smells from the keeping or feeding of animals.”

For questions about rule applicability or interpretation, you may call one of the following:

ODA
Division of Soil and Water Conservation
Phone: (614) 265-6610

Ohio EPA
Division of Materials and Waste Management
Composting Program
Phone: (614) 644-2621

CHAPTER 7

Economics of Composting

Terry Mescher, ODA, Division of Soil & Water Conservation

Before committing to composting, livestock producers should evaluate all options of addressing animal mortality available to them, including rendering, burial and incineration. The most economical solution for addressing animal mortality may not be the same from region to region in Ohio and will even vary from producer to producer within a region. The variability in options available to producers and the variability of costs associated with the different options necessitates that each producer must individually evaluate the options to determine the most economical choice for their operation.

The following discussion provides some general economic considerations for alternatives to composting as well as specific guidance on considerations for composting animal mortality.

Burial

Burial can be a viable and economical option for animal mortality for some producers, particularly for those with small herds and minimal death loss and who already own the necessary excavation equipment. When considering burial, a producer needs to weigh the following factors:

- Will excavation equipment need to be purchased or rented? Estimated equipment rental costs are $85 - $100 per hour.
- Are there hydrogeologic challenges that will make burial difficult or impossible, such as shallow bedrock or high groundwater, or proximity to water wells or groundwater that are susceptible to pollution?
- Weather conditions may frequently inhibit burial operations and necessitate storage of mortality or disposal offsite.
- Time and/or hired labor will be necessary to complete burial operations.

Incineration

Incinerators for livestock are generally used in poultry operations and provide some operational advantages over composting, including smaller space requirements for the equipment compared to composing facilities, reduced biosecurity risks, and minimal residual material (ash) to handle. Economic considerations for incineration should include:

- New equipment will need to be purchased and installed. Incinerators range in price from $10,000 to $20,000.
- At the time of writing, estimated costs for incineration operation range from $0.15 to $0.50 per pound.
- Equipment maintenance and upkeep costs.

- Cost and availability of fuel sources including liquid propane, natural gas, and diesel. Volatility of fuel prices should be a consideration as well. Plan for increasing fuel costs.
- Some producers in Ohio may have access to a certain amount of free natural gas from their land if natural gas is being produced from their land.
- Labor required to operate the incinerator.

Rendering

Across Ohio there are a limited number of rendering facilities that may accept or pick up livestock mortality. These facilities will charge an amount per animal or pound and may also pick up livestock for an additional fee. An economic analysis of this option can easily be made once a producer locates any available rendering facilities and acquires their fee schedule. Other considerations for rendering include:

- Temporary storage of livestock mortality may be necessary depending on pickup schedules.
- Additional biosecurity concerns with traffic to or from the rendering facility.
- Time and fuel required for hauling livestock loss to the rendering facility.

Composting Facilities

The overall economics of composting animal mortality is dependent on three primary variables. They are **Facility Costs**, **Bulking Agent Costs**, and **Management Costs**. Comparing the overall economics of composting mortality compared to other options is difficult and relies on many variable costs such as lumber, concrete, sawdust, etc. Again, the producer will need to establish the specific costs for each of these variables in their area to make an informed decision.

Facility Costs

Before pursuing newly constructed composting facilities, producers should evaluate their existing infrastructure. There may be opportunities to use underutilized hard surfaces and roofed areas. For example, covered manure storage areas may have some excess capacity that could be used for composting. Additionally, if a producer intends to construct new covered manure storage, it will likely be more economical to increase the manure storage size to accommodate composting rather than building a standalone structure for composting.

Mortality composting can be successfully completed within roofed bin systems, as well as on an all-weather gravel pad in a pile or windrow. While a simple gravel pad will certainly have the lowest capital costs, it will come with additional management challenges. Composting operations require regular access to the site and must ensure a complete composting process regardless of weather conditions. For this reason, composting facilities with a concrete surface and a roof are highly recommended.

Composting operations completed on a gravel pad or without a roof are more susceptible to adverse weather conditions resulting in management challenges. Excessive rainfall can saturate some bulking materials used in the composting process and result in leachate from unroofed composting sites. Windy conditions can result in bulking agents and covering materials being blown off the pile, exposing mortality to the elements.

Covered composting facilities may allow the livestock producer to utilize alternate bulking agents that cannot be used without a roof. Sawdust is the most commonly recommended bulking agent for all mortalities except poultry. Sawdust provides ample carbon for the composting process, allows adequate air movement to support microbes, and typically does not get saturated from rainfall. Access to sawdust as a bulking agent can be a challenge in certain areas of the state and can be costly at times.

Costs for composting facilities vary widely based on the size of the facility and the design selected. Typical cost for concrete covered bin facilities typically range from $4000 to $6000 per composting bin. Costs for non-covered bin systems commonly range from $2000 to $3500 per bin.

Concrete pads for windrow composting facilities typically cost $8 to $10 per square foot. Overall pad size is dependent on the specific operation; however, pad widths of 30 to 40 feet and pad length of 50 feet or more are common.

Costs of materials for construction tend to be volatile as demand fluctuates based on factors such as pandemics, hurricanes, labor availability, etc. When evaluating facility options, it is paramount to obtain estimates for the work at that time and from local contractors to have an accurate picture of the construction costs. Opportunities for financial assistance for the construction of compost facilities may be available through NRCS's Environmental Quality Incentive Program (EQIP) for some producers. Producers should explore these opportunities with their local SWCD/NRCS office.

Windrow composting facilities are usually less costly to construct compared to roofed bin systems. However, operating costs and management requirements of windrow systems are generally significantly higher.

The lifespan of constructed facilities should also be taken into consideration when evaluating different composting options. Concrete floors and sidewalls for bin systems will have lifespans of 20-30 years. Tongue and groove treated lumber for sidewalls will generally be cheaper up front than concrete but will likely not last beyond 10 years before needing to be replaced. Wood side walls will also not take abuse as well from equipment.

Bulking Agent Costs

Bulking agents are needed for composting of animal mortality. Bulking agents must provide carbon to the microbes responsible for the composting process and adequate air flow to maintain an aerobic environment around the animal carcass. Sawdust is the recommended bulking agent for non-poultry mortality.

Availability of sawdust varies dramatically across the state and will generally dictate the cost. Local industry may provide sources of free or reduced cost bulking material. Follow the guidance in this manual regarding the use of different bulking agents and carbon sources but consider potential sources, which may include woodchips from tree trimming providers, sawdust from any industry that creates wood products (furniture makers, pallet production, lumbermills), and food waste such as peanut hulls.

Roofed composting facilities may allow livestock producers to utilize other materials to supplement sawdust used for the composting process. Alternatives include waste feed or silage, pen pack manure, straw, etc. Use of these materials can reduce the costs of bulking agents used for composting but must be managed properly to ensure proper composting. Producers interested in using alternative materials should seek advice prior to starting the process.

Management Costs

Beyond the costs of infrastructure and bulking agents, consideration needs to be given to the costs associated with management. These costs will include the time or labor expenses associated with managing the compost system, fuel and equipment costs, and maintenance of the compost facility.

As producers are increasingly occupied with other farm work or off-farm work, care should be taken to value the time that will be required to manage a compost system. Producers will need to factor in their own time to manage a system or the labor costs for hired work to manage the compost. Time requirements will be proportional to the amount of death loss. Time and/or labor will be required for:

- Acquiring bulking material.
- Adding livestock mortality and covering initially.
- Periodic management of existing compost piles.
- Utilizing finished compost via land application.

Equipment will be necessary in most cases for transporting livestock mortality, managing the piles, and utilizing the finished compost. Often this equipment will already be available on the farm, but if not, the cost of purchasing the equipment will need to be factored in. Additionally, a certain amount of fuel and maintenance for use of the equipment for composting will need to be included.

As stated at the beginning of this chapter, the most economical solution for addressing livestock mortality must be determined individually for each producer. Localized costs, availability of composting alternatives, the producer's existing facilities and equipment, availability of bulking agents, and management costs will all impact the final decision.

CHAPTER 8

Troubleshooting and Frequently Asked Questions

Tom Price, Pork-Q-Pine Farms and
Michael J. Monnin, PE, NRCS

Composting is a biological process that depends on providing nutrients and an environment favorable for vigorous bacterial growth. When properly constructed and managed, composting systems are a cost-effective and environmentally safe option for dead animal disposal. Frequently asked questions are discussed below and probable causes and solutions to typical problems are summarized in Table 8-1.

Occasionally, composting material will not heat up, or will produce odors or seepage. Some of the most common mistakes are:

- Failure to provide enough carbon amendments, especially sawdust, needed for optimal microbial decomposition, biofilter, and aeration. Sow unit composting facility employees often deal with large volumes of afterbirth and need to be sure sufficient dry carbon amendment is available for proper mixing.
- Sloppy loading of animals and amendments.
- Insufficient cover over the animals.
- Insufficient sawdust between the animals.

These mistakes typically result in a wet, dense mass that leads to anaerobic conditions. Turning the pile and adding DRY sawdust will usually remedy these problems. Daily records are the best way to diagnose problems. Exposed piles or windrows seldom need additional water.

Frequently Asked Questions

1. Doesn't mortality composting produce offensive odors, and attract rodents and dogs?
If animals are properly covered (1 ft. sawdust for bins and 2 ft. for windrows or piles), odors are sufficiently suppressed or absorbed so they are not a problem in most cases. When properly operated and managed, composting does not add to or increase odor levels around a production facility. Using too little sawdust is the single greatest factor associated with odor and rodent or scavenger problems. It is important to prevent these problems during start up because once scavengers learn the composting system is a source of food, they can be difficult to stop.

2. What happens in the wintertime when temperatures are cold?
In general, the warmer the ambient temperature, the better the composting process works. However, an active composting unit generates considerable heat, which with the insulating effect of sawdust, can retain heat during periods of colder ambient temperatures. Interior composting unit temperatures of 130 to 160 ^{o}F are typical in properly operating units, even when ambient temperatures are as low as 0 ^{o}F. Cold or frozen animals placed in cold, fresh sawdust will not compost during cold weather. However, animals placed under these conditions will begin to compost as ambient temperatures increase in the spring.

Animals placed in an active composting unit during cold weather should begin to compost as heat is absorbed from the composting mass. Covering the animals with warm or hot finished compost from an active secondary composting unit will further enhance the composting of fresh animals in cold ambient temperatures.

3. Is a roof and concrete floor necessary?

It has been observed that a roof is not necessary when sawdust is used as the carbon amendment. Sawdust has the unique ability to shed water and if kept on a dry and well-drained base, will not cause leachate. Until research proves otherwise, a roofed structure will be required unless:

a) sawdust is used as the carbon amendment, and
b) an all-weather, dry, positively drained composting surface is used and all-weather access is maintained, and
c) the runoff and any possible leachate are collected and stored or treated in a storage or filter area.

4. How large a mortality can be put into a composting system?

Mature sows and boars (300 to 600 lbs.) and cattle (1000 lbs.+) have been successfully composted. Longer composting times are required for the larger animals. Four months of active composting should be sufficient for most swine mortalities. The animals are composted whole; no cleaving or cutting up is necessary. If certain parts, such as the skull or ball joints are not fully composted, reintroduce them to the primary composting process for another stage. If this is happening a lot, look for reasons the process is being slowed. Often, it is because not enough sawdust is being added to the system.

5. Do composting systems fail and, if so, why?

Occasionally, yes. The composting material may not heat, producing odors and/or creating seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for bacterial decomposition. Common mistakes include:

a) failure to provide enough sawdust to the system to provide for the biofilter and to maintain an appropriate carbon source for the system to operate over time, or
b) placing animals too close together, which may create a large anaerobic mass that will need to be turned and dry sawdust added.

In windrow composting, the pile must be well rounded to shed water and the base and surrounding apron must be solid and well drained to allow for access and prevent anaerobic conditions.

The problems with too-wet, improperly mixed, or incomplete mixes of compost materials can be corrected. When primary stage compost is turned, dry sawdust may be added to wet compost, and improperly mixed materials can be re-mixed. A little experience and perseverance usually give good results in a short time.

6. Can finished compost be used as a partial or full substitute for fresh sawdust in the primary stage?

Experience to date indicates that finished compost can replace up to 50% of the fresh sawdust requirement. The long-term viability of the process cannot be maintained if fresh sawdust is not added, because the source of carbon will eventually be exhausted. Advantages of recycling finished compost include less fresh sawdust needed, active bacteria and heat provided from the finished compost, and less finished compost to haul for land spreading.

7. What about diseases, flies, and pathogens?
Fly breeding typically has not been a problem. However, if positive drainage is not maintained, or rutting or ponding of water occurs, or the compost materials are above 60% moisture, flies can be a problem. The answer is the proper location and construction of the composting area so there is no free-standing water, positive drainage is maintained to the collection area, and the windrows are rounded to limit infiltration of rainwater.

Exposed animal parts will invite flies and scavengers, compromising biosecurity. Buzzards are an example of a scavenger that is difficult to stop once accustomed to feeding from a mortality composting facility. Properly covering all animals with 2 ft. of sawdust is critical.

In a properly constructed composting pile or windrow, temperatures will rise above 135 ^{o}F for greater than a three-day period, which has been shown to eliminate pathogens associated with swine production. No disease outbreak has been associated with composting to date. It is recommended that composting occur on site, eliminating the spread of disease associated with transporting dead stock. Spreading finished compost on fields or pastures helps assure that disease organisms do not find their way back to the production area.

8. What should finished compost look like?
Properly finished compost should appear as a dark granular material that resembles humus or potting soil. It should have the feel of moist soil and may have a slight musty odor. Some resistant bones will be visible, but should be brittle and easily crumbled.

9. If I do not have sawdust available, can I use another carbon amendment?
YES, however you may need to compost in a roofed structure

Any granular organic material with a high carbon content should be a candidate as an ingredient in composting. Successful swine composting without the use of a roofed structure has been accomplished using sawdust as the carbon amendment or carbon source. More research and experience are needed to evaluate other carbon sources such as straw, hay, corn stalks, or rice hulls. A long fibrous material, such as cornstalks or straw, would likely work better for composting if it were ground to reduce the particle size, similar to that of sawdust. This would allow the material to settle around the mortality and provide the contact needed for good bacterial activity. Composting structures for swine have successfully utilized straw and poultry litter as the carbon and nitrogen source. It is necessary to construct a structure with a roof, concrete floor, and concrete or treated timber walls for these systems. Their success has been documented and design criteria are available.

10. What should I do with finished compost?
For on-farm facilities, finished compost in the secondary compost unit, that is not recycled to the primary unit, can be used on-farm by spreading per the compost utilization plan. Conventional "beater type" manure spreaders are ideal for handling and

spreading compost. Remember that if the compost if going to be used off-farm, it must be tested according to the quality standards established by Ohio EPA.

For off-farm facilities regulated by Ohio EPA, the compost has to meet the required quality standards, unless the compost is going to be used on property owned by the same owner of the facility.

11. Can I compost in just one step, rather than moving the material from primary to secondary windrows or bins?

Moving compost from primary to secondary windrows or bins provides mixing, adds oxygen, and allows the compost to "finish off" with a high degree of breakdown. The success of the primary/secondary approach has been demonstrated in many other areas of composting, as well as mortality composting. Some producers have reported acceptable results with single step composting, but the total composting time can be longer than the primary/secondary composting time. Also, bin or windrow volume requirements are not reduced by single-step composting. Facilities regulated by Ohio EPA are required to use a two-step process, at a minimum.

12. What about using "green" or wet sawdust?

Generally dry sawdust is better since it can absorb more water and contains more air space. Producers have reported success using green sawdust for some or all of the fresh sawdust requirements. Sawdust containing excessive moisture may freeze in the winter, making it difficult to handle and place around the animals. A compost windrow with a moisture content greater than 60% increases the risk of leachate, anaerobic activity, and fly production. Aged sawdust of 40- 50% moisture content is recommended.

Table 8-1. Compost Troubleshooting Guide*

Problem	**Probable Causes**	**Suggestions**
Temperature does not rise to desired level.	1. Too dry 2. Too wet	1. Add water. 2. Turn and aerate, add more carbon amendment if needed.
Temperature does not stay at desired level long enough.	1. Compost may have dried out.	1. Break crust and add additional water.
Breakdown of materials does not occur. Small animals may be "mummified".	1. Adequate moisture may not be available. 2. Inadequate nitrogen source for small animals. 3. Small pile with cold ambient temp. Does not have sufficient mass to maintain activity.	1. Add water. 2. For small animals add dry manure (poultry if available) to achieve desired recipe. 3. Leave pile intact until ambient temperatures rise or add to larger active primary pile.
Odor – high sulfur	Compost is anaerobic (needs oxygen) if:	1. Reconstruct pile with more carbon amendments

	1. Compost is too wet 2. Not enough carbon amendment 3. Bin is airtight.	and fresh sawdust for exterior cover. 2. Do not use solid sides. Construct to permit air flow.
Odor – decay	1. Animal layer is too thick or too close to the sides or top	1. Re-layer the animals and cover sides and top well.
Odor – ammonia	1. Improper C:N ratio	1. Add more fresh sawdust to cover material
Flies	1. Improper storage of manure. Keep it dry. 2. Failure to reach high temperatures. Incomplete composting.	1. Cover manure. 2. Cover pile with fresh carbon amendment. If small animal or secondary stage, remix before adding fresh cover. Check temperature to monitor compost response.

* adapted from materials by Dr. A. J. Pescatore and Dr. W. O. Thom, Agricultural Science

APPENDIX A

USDA Natural Resources and Conservation Service (NRCS) Resources

The following USDA NRCS resources provide guidelines:

1. Worksheets for calculating death loss:
   a. NRCS-OH-ENG-233a: General livestock death loss calculation (page 57)
   b. NRCS-OH-ENG-233s: Swine production death loss calculation (page 59)
   c. NRCS-OH-ENG-233p: Poultry production death loss calculation (page 60)

2. Worksheets for calculating volumes, pad dimension, and bin numbers:
   a. NRCS OH-ENG-234a: Worksheet to determine pad size for windrows (page 61)
   b. NRCS OH-ENG-235a: Worksheet to determine number of bins for composting (page. 63)

3. Preventing Fires in Litter Storage Structures (from NRCS Alabama Guide Sheet 313). (page 65)

4. Standard Drawing OH-NRCS 506 – CAD, Composting facility (page 67)

5. Conservation Practice Standard, Animal Mortality Facility, Code 316 | Access online: https://efotg.sc.egov.usda.gov/api/CPSFile/22504/316_OH_CPS_Animal_Mortality_Facility_2019

NRCS OH-ENG-233a (12/1999; pg 1)**: General livestock death loss calculation**

Cattle, horses, sheep, goats, other (specify)__________, poultry (use 233p), swine (use 233s) *Complete one form for each livestock species. When the composting facility will include multiple livestock species, calculate daily losses by animal growth stage for each species, then sum the species worksheets to determine daily farm loss (see bottom of form).*

Total pounds of death loss per year (use "**average weight**" to calculate death loss)

Birth stage:

(________________) x (_______________) x (_______________) = __________
Number of births — Average weight — (% loss/100) — lbs. of annual mortality

Weanling stage:

(________________) x (_______________) x (_______________) =____________lbs. of
Number of animals — Average weight — (% loss/100) — annual mortality

Yearling stage:

(________________) x (_______________) x (_______________) =____________lbs. of
Number of animals — Average weight — (% loss/100) — annual mortality

Mature stage:

(________________) x (_______________) x (_______________) =_____________lbs. of
Number of animals — Average weight — (% loss/100) — annual mortality

Total Annual Mortality per year (**AM**) =_____________lbs. of annual mortality

Average Daily Loss (ADL) = **AM ÷ 365** = __________÷ 365 =_______lbs/ day

Notes: For animals weighing less than 500 – 600 pounds, a bin composting system may be a viable design option. For larger animals, a windrow or compost pile for an individual mature animal will likely be the most practical.

For poultry and swine, average daily death loss can be assumed to be constant throughout the year. However, in some livestock operations, high seasonal death rates are the norm, such as during calving and lambing, where most of the annual death loss occurs during a short period of time. Another example is where specific growth stages are moved off the farm at less than a year old (e.g., lambs sold at 120 days). In these instances, the average daily death loss calculation is modified as follows:

Daily death loss (ADL) = (AM × P) ÷ t =______lbs/day, where:

AM = total annual mortality, for species or growth stage (lbs.)
P= percentage of total annual loss that occurs during seasonal peaks (decimal)
t = duration of seasonal high loss period, or duration of species are on the farm if less than 1 year (# days)

NRCS OH-ENG-233a (12/1999; pg 2): General livestock annual death loss calculation

Optional ADL calculation method

Birth stage:
(ADL) = (__________ × __________) ÷ ________= ___________lb/day
AM P t

Weanling stage:
(ADL) = (__________ × __________) ÷ ________= ___________lb/day
AM P t

Yearling stage:
(ADL) = (__________ × __________) ÷ ________= ___________lb/day
AM P t

Mature stage:
(ADL) = (__________ × __________) ÷ ________= ___________lb/day
AM P t

Total ADL/species = __________ lb/day

Total farm ADL (complete for each species and total)

Species	**Daily mortality** (ADL) from forms 233a, 233p or 233s
Cattle/dairy	lbs./day
Goats	lbs./day
Poultry	lbs./day
Sheep	lbs./day
Swine	lbs./day
Horses	lbs./day
Other (list)	lbs./day
Sum (total	lbs./day

Go to forms 234a (windrow) or 235a (bin) to size the composting facility

NRCS OH-ENG-233s (12/1999)**: Swine production and death loss calculations**

Stage of growth	**Average weight** (lbs)	**Design weight** (lbs)	**Mortality losses for swine production** (%) Excellent	Good	Poor
Birth to weaning	6	10	Under 10	10–12	Over 12
Nursery	24	35	Under 2	2–4	Over 4
Growing/finishing	140	210	Under 2	2–4	Over 4
Breeding herd	350	350	Under 2 / yrs.	2–5 / yrs.	Over 5 / yrs.

Source: Pork Industry Handbook - 100

Production

Number of pigs born per year (pre-weaning):

______________ × ______________ × ______________ = ______________

(# sows) (litters/yr) (pigs/litter) # pigs born/year

Number of nursery pigs per year:

______________ - (______________ × ______________) = ______________

(# pigs born/yr) (# pigs born/yr) (% loss/100) # nursery pigs/year

Number of finishing hogs per year:

______________ - (______________ × ______________) = ______________

(# nursery pigs/yr .) (# nursery pigs/yr) (% loss/100) # finishing hogs/year

Total Pounds of death loss per year (use "**average weight**" to calculate death loss)

______________ × ______________ × ______________ = ______________

(# sows) (Average weight) (% loss/100) pounds loss/year

______________ × ______________ × ______________ = ______________

(# pigs born/ yr.) (Average weight) (% loss/100) pounds loss/year

______________ × ______________ × ______________ = ______________

(# nursery pigs/ yr.) (Average weight) (% loss/100) pounds loss/year

______________ × ______________ × ______________ = ______________

(# finish hogs/ yr.) (Average weight) (% loss/100) pounds loss/year

Total annual mortality per year (**AM**) = __________ lbs/year

Average daily loss (ADL) = **AM ÷ 365**=__________÷ 365 =__________lbs/ day

NRCS OH-ENG-233p (12/1999): Poultry production and death loss calculations

	Poultry[1] Average weight[3] (pounds)	Loss rate (%)	Flock life	Design weight[4] (pounds)
Broiler (mature)	4–8	4.5–5	42–49 days	Up to 8
Layer	4.5	14	440 days	4.5
Broiler, breeding hen	4–8	10–12	440 days	8
Turkey, female (meat)	15–25	6–8	95–120 days	25
Turkey, male (meat)	25–42	12	112–140 days	35
Turkey, breeder replace.	15 (birth–30)	5–6	210 days	20
Turkey, breeding hen	28–30	5–6	180 days	30
Turkey, breeding tom	70–80	30	180 days	75

Source: Ohio Poultry Association information

Poultry type: ___________________________

B = Number of birds on farm = _____

M = Anticipated mortality for flock (as a decimal) = __

T = Life of flock (days) = _______________

W_b = Weight of birds near maturity (lbs) = _____

ADL = Average daily loss during flock

life (lbs/day) ADL = B x [(M/T) x W_b]

ADL =_______× [(___÷___) ×______] =_______lbs/day

Go to form OH-ENG 235a to size the bins.

Recipe of material proportions for poultry composting

Material	Parts by weight (lbs)
Poultry carcasses	1.0
Poultry litter	1.2
Straw	0.1
Water	0.75

NRCS OH-ENG-234a (12/99**): Worksheet to determine pad size for windrows.**
(Assumes 2 windrows per pad)

1. Calculate primary, secondary, and storage volumes.

Primary volume = 0.2 ×_____________× X days =___________cubic feet (X from table)
lbs loss/day Primary-stage time

Secondary volume = 0.2 ×__________× X days=_____________cubic feet (X from table)
lbs loss/day Secondary-stage time

Storage volume = 0.2 ×_____________× 30 days =___________cubic feet
lbs. loss/day

Alternate Equations: (use with large animals)

Primary volume = 0.2 × W1 (lbs.) ×integer (ADL × T1/ W1) = ________cubic feet
Secondary volume = 0.2 ×W1 (lbs.) ×integer (ADL ×T2/ W1) = ________cubic feet
Storage volume = 0.2 × W1 (lbs.) × integer (ADL ×T3/ W1) = ________cubic feet

2. Indicate the windrow height and resulting windrow area required.

Windrow height =______________feet, Windrow area and base width are based on 1 foot top width and 1:1 side slopes.

Windrow height (feet)	Windrow x-section area (square feet)	Windrow base width (feet)	Pad width (feet)
5	30	11	52
6	42	13	56
7	56	15	60

3. Calculate the length of the primary, secondary and storage windrows. ****The design windrow length is the longer of the primary windrow length or the sum of the secondary and storage windrow lengths.*** Then calculate the pad length.

Primary windrow length = (_____________) ÷ (_____________) =_____________feet
Primary volume Windrow area (nearest foot)

If the composting windrow length is less than twice the windrow height, reduce the height and go back to step 2. This indicates the composting configuration will be a compost pile versus a windrow.

Secondary windrow length = (____________) ÷ (____________) =____________feet
Secondary volume Windrow area (nearest foot)

Storage windrow length = (_____________) ÷ (_____________) =_____________feet
Storage volume Windrow area (nearest foot)

Pad length = **Design windrow length + 10 ft. =_____________feet
(nearest foot)

4. Calculate composting pad area. Pad width = 10 feet + first windrow base + 10 feet. + second windrow base + 10 feet. The 10-ft strips allow movement for mixing and turning. (See table in step 3)

Compost pad area =____________x___________=____________square feet
Pad length Pad width

5. Calculate annual sawdust requirements. (This assumes no reintroduction of finished compost to the primary windrow. However, it is recommended that up to 50 percent of fresh sawdust requirements can be met with finished compost.)

Cubic yards sawdust =______________× 0.0069 =__________cubic yards/year
TOTAL lbs loss/year

NRCS OH-ENG-235a (12/1999; pg 1)**: Worksheet to determine number of bins for composting**

1. Calculate primary, secondary and storage times (or use tables 3-3, 3-4):

Primary stage time (T_1) = 5 x $\sqrt{W_1}$ = ____ days (W_1 = Design weight of largest animal, lbs.)

Secondary stage time (T_2) = 1/3 x _________(T_1) = ____________ days
(Primary stage time) (10 day minimum)

2. Calculate primary, secondary and storage volumes (or use tables 3-8, 3-9, 3-10):

Primary volume = 0.2 ×_______________× ___________ days =_________cubic feet
lbs loss/day (ADL) Primary-stage time (T_1)

Secondary volume = 0.2 ×____________× ___________ days =_________cubic feet
lbs loss/day (ADL) Secondary-stage time (T_2)

Storage volume = 0.2 ×______________× 30 days =____________cubic feet
lbs. loss/day (ADL)

Alternate Equations: (use with large animals)

Primary volume = 0.2 × W1 (lbs.) ×integer (ADL × T1/ W1) = ________cubic feet

Secondary volume = 0.2 ×W1 (lbs.) ×integer (ADL ×T2/ W1) = ________cubic feet

Storage volume = 0.2 × W1 (lbs.) × integer (ADL ×T3/ W1) = ________cubic feet

3. Calculate number of bins. Minimum of two primary, one secondary, and one storage bin required. *When completing calculations always round up to whole number, i.e. 2.1 bins = 3 bins (or) increase the bin size and recalculate.*

Bin volumes versus width and length; depth of compost = 5 feet

Width / length	**4**	**6**	**8**	**10**	**12**	**14**	**16**
	Bin volume (feet^3)						
4	80	120	160				
6	120	180	240	300	360		
8	160	240	320	400	480	560	640
10		300	400	500	600	700	800
12		360	480	600	720	840	960
14		420	560	700	840	980	1120
16		480	640	800	960	1120	1280

Number of primary bins - Choose bin dimensions within the capability of the loading equipment. Also account for the size of the animals to maintain 6–12 inches of clearance between the carcasses and the bin walls (minimum volume). The bin width should be at least 2 feet greater than the loader-bucket width. The equation for calculating the number of primary bins includes one additional bin to allow placing additional carcasses during the primary curing stage. *A minimum of two primary bins is required.*

Trial bin volume =____________× _____________× 5 feet =_______cubic feet
width (feet)   length (feet)

Number of primary bins = _____________ ÷ __________+ 1 bin =__________bins
Primary volume (step 2)   Trial bin volume

Number of secondary bins—Select secondary bin volume. *Each secondary bin must be greater than or equal to the volume of the primary bin since volume reduction during the compost stage is neglected.* A minimum of one secondary bin per three primary bins (The 3:1 ratio requires immediate utilization or separate storage of compost following the secondary stage.)

Number of secondary bins = _____________ ÷ _____________ = ____________bins
Secondary volume (step 2) Secondary-bin volume

Number of storage bins - Select storage bin size. *Volume of each storage bin must be greater than or equal to the secondary bin volume.*

Number of storage bins = _________________ ÷ ____________ = ___________bins
Storage volume (step 2)   Storage-bin volume

4. Calculate annual sawdust requirements. (This assumes no reintroduction of compost that has completed the secondary cycle into the primary bin. However, it is recommended that up to 50% of fresh sawdust requirements be met with this compost.)

Cubic yards of sawdust = ________lbs. loss / yr.× 0.0069 =________cubic yards/year

Additional bin(s) for fresh sawdust storage = ____________ bins

Summarize bin sizes and numbers:

	Primary	**Secondary**	**Compost storage**	**Sawdust storage**
Number of bins				
Size (width x length)				

Preventing Fires in Litter Storage Structures

(from NRCS Alabama Guide Sheet 313)

DEFINITION

Litter stacks and even dead animal compost can catch fire if not properly maintained. Storing poultry litter in a covered storage structure is a good management technique. It provides flexibility in timing land applications of compost; prevents the possibility of polluting surface or ground waters, which could occur with litter stored outdoors; and is a good way to maintain quality feed for cattle. However, careful management practices must be used to prevent fires.

OPERATION AND MAINTENANCE

Background Information

It has long been known that heat is generated when microbiological activity occurs in an insulated environment, such as a garden compost pile or even dairy manure stored outside. Overheating and spontaneous combustion in hay barns, coal piles, landfills, and barrels of oily rags are not uncommon. Both biological and chemical factors may be associated with litter storage fires, although the exact causes are not fully known.

Fires and explosions have occurred in unvented sanitary landfills due to the generation of combustible methane. In order for methane to be generated, conditions, which include proper moisture content (greater than 40%) and an oxygen-free or low-oxygen environment, must be right for the growth of anaerobic bacteria. Methane has a specific gravity less than air and, therefore, can escape to the atmosphere if a proper conduit is provided (i.e., adequate pore spaces in the surrounding litter). Methane is flammable in air at concentrations of 5 to 15%. As such, the production of methane in litter storage is a potential hazard.

Another phenomenon, called the heat of adsorption, can occur when dry matter such as litter comes into contact with moist material or even moist air. As the dry material adsorbs water vapor, heat is released. In an insulated environment this generated heat can be significant. The heat from this process begins to dissipate when the moisture occupies or is adsorbed to all the available attachment sites in the dry material.

However, another process, called pyrolysis or heat of oxidation, can take over at higher temperatures, usually between 250° to 400°F. This process is self-sustaining as long as adequate oxygen is available.

Thus, the processes which relate to the generation of heat are both biological and chemical. However, since most bacteria are killed between 130° and 165°F, chemical reactions are ultimately responsible for the processes that lead to combustion.

The Delaware NRCS, Cooperative Extension Service, and Conservation Districts conducted a survey of poultry producers to identify management practices which tended to cause fires and overheating in dry stacks. From the 80 producers interviewed, the researchers found that seven dry stacks had experienced one or more fires. An additional twelve experienced excessive heat during the storage period. A statistical analysis did not reveal a single common cause of all fires, but it did reveal that common factors were prevalent in nearly all cases.

Study Findings

MOISTURE: Moisture was found to be a critical factor in all manure pile fires. All structures having fires had litter from houses with Plasson® waterers or water troughs in some or all the houses. One pile was also exposed to wind-driven rain. These findings suggest that higher moisture levels caused more heat to be generated in the piles.

LAYERING: Piles which experienced fires were all layered either horizontally (new litter stacked on top of old) or at an angle (litter pushed against the sloping sides of old litter). (NOTE: Layering brings into contact old litter, which can be very dry, and new litter, which may be moist. The boundary between the two layers becomes an insulated, heat-producing area.)

COMPACTION: The majority of piles that experienced fires were compacted. Heat is not easily released from a compacted pile.

PILE SIZE: The pile height and width were found to be more critical than pile length. The larger the pile size (cross sectional area) the greater the chance for excessive heat or fire. Heat is more easily released from a smaller pile because of its larger ratio of surface area to volume.

RECOMMENDATIONS

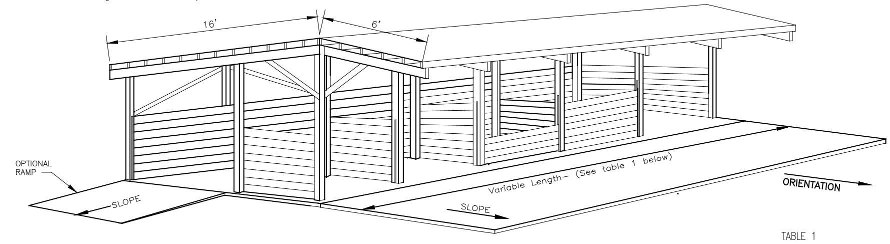
In order to reduce the potential for fires in litter storage structures the following is recommended:

1. Pile height should not exceed 7 feet. Storing the material in separate small windrows reduces the cross-sectional area and is the safest option for stacking.
2. KEEP THE LITTER DRY! Don't wet the litter in the hope of preventing a fire; just the opposite may occur. In addition, protect the litter from blowing rain.
3. Avoid placing the wet material in contact with dry material. Don't layer new litter on top of old, and don't let dead poultry compost come into contact with stored litter.
4. Don't compact the material by driving over it or packing it with equipment.
5. If litter is stored against wooden walls, limit height to 4 feet and monitor temperatures in this area daily. If temperatures cannot be monitored regularly, do not store litter against wooden walls.
6. Monitor temperatures at different points in the pile frequently. If temperatures exceed 190°F, or if the material is smoldering, prepare to remove material from the building. This includes notifying the local fire department to be on hand. A smoldering pile could burst into flames if exposed to air. A garden hose could be inadequate to extinguish the fire.
7. Do not store expensive equipment in the litter storage structure.

HOME

NRCS Standard Drawing OH-N 506- CAD (4 sheets)

NOTE
For clarity, view is shown without enclosures (above primary bin on near end and storage bin on far end).



PERSPECTIVE VIEW
NOT TO SCALE

TABLE 1

No. of Primary Bins	Total * Length Feet–In.
2	26'–4"
3	34'–11"
4	43'–6"
5	52'–1"
6	60'–8"
7	69'–3"
8	77'–10"

* Includes one 8' wide storage bin.

NOTES
1. This plan set shows details for a four (4) primary bin unit. The plan set is to be adapted for _____ primary bins and _____ storage bins.
2. The Ohio Construction Specification for Composting Facilities is to be used as a part of this plan set.
3. The composting facility shall be located 300 feet from any well. The facility floor shall be 3 feet above bedrock or the highest ground water elevation.
4. An equivalent roof design shall provide for a uniform load to meet the county code or 20 psf, which ever is greater.

Estimated Quantities *

Item	4 Primary Bin Unit **	Each Additional Primary Bin
6" x 6" Posts	260 lin. ft.	44 lin. ft.
4" x 6" Posts	24 lin. ft.	6 lin. ft.
4" x 4" Posts	45 lin. ft.	8 lin. ft.
2" x 8" Planks	1240 lin. ft.	220 lin. ft.
2" x 6" Planks	84 lin. ft.	14 lin. ft.
2" x 4" Planks	880 lin. ft.	162 lin. ft.
Concrete	20 cu. yds.	4 cu. yds.
Sand and Gravel	25 cu. yds.	5 cu. yds.
Wire Mesh Reinforcement	1240 sq. ft.	228 sq. ft.

* Does not include any optional items listed on sheet 2 or cutting losses for wood members.
** Includes one 8' wide storage bin.

THIS STANDARDIZED DESIGN MUST BE ADAPTED TO THE SPECIFIC SITE. IT WAS PREPARED AT THE SCS STATE OFFICE, 200 NORTH HIGH STREET., RM 522, COLUMBUS, OHIO 43232, FROM A STANDARD DETAIL DEVELOPED IN MADISON, WISCONSIN.

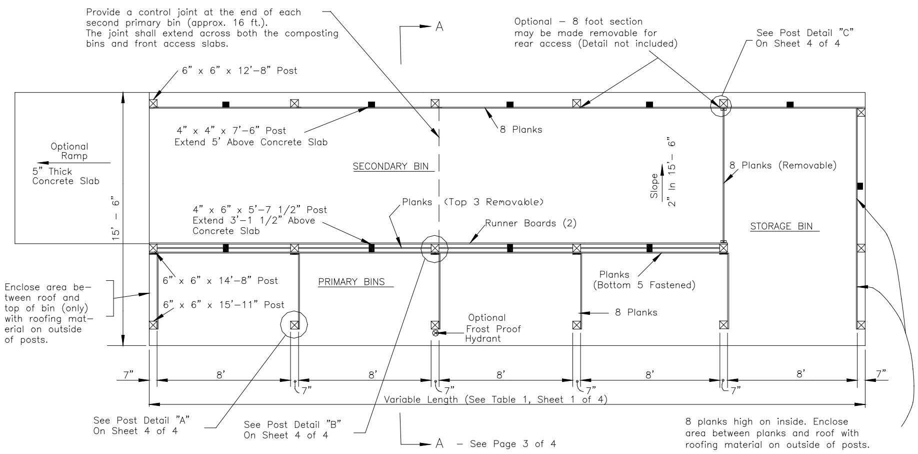
OHIO SCS DESIGN SECTION

STANDARD DRAWING NO.: OH–N–506–CAD
APPROVAL DATE: 07/94
REVISIONS:

COMPOSTING FACILITY, DEAD BIRD
PRODUCER ____________
COUNTY ____________

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	Approved by
Designed	DDR	5–92	Title
Drawn	BES	4–93	
Revised	KW	8–94	Title
Checked	AB	8–94	Sheet No 1 of 4



FLOOR PLAN

NOTES:
1. CCA treatment on all lumber except rafters, purlins, knee and cross braces shall be 0.4 pounds per cubic foot as per American wood–preservers Association Standard C–2, for soil and fresh water use.
2. Planks are to be 2" x 8" treated wood of variable lengths.
3. Cleats to secure removable planks may be 2" x 2" wooden cleats or 2" x 1 1/2" angle iron (see details sheet 4 of 4).
4. Top 3 planks between primary and secondary bins are to be removable. Support with 2" x 6" blocks attached to both sides of post.
5. Attach purlins to rafters with manufactured framing anchors.
6. Minimum purlin length shall be 10'–0".

OPTIONAL ITEMS
(to improve entry and exit with equipment)
(a) Double wall along sides of primary bins with 2" x 6" cap.
(b) Double wall between secondary bin and primary bins with 2" x 8" top cap.
(c) Concrete slab at end of secondary bin.

OHIO SCS DESIGN SECTION

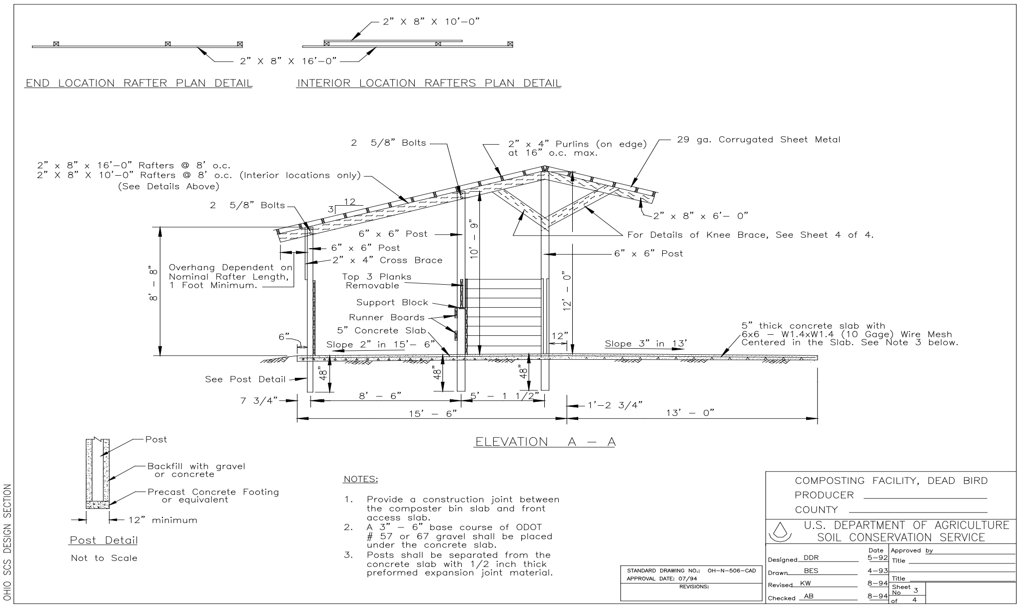
STANDARD DRAWING NO.: OH–N–506–CAD
APPROVAL DATE: 07/94
REVISIONS:

COMPOSTING FACILITY, DEAD BIRD
PRODUCER ____________
COUNTY ____________

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	Approved by
Designed	DDR	5–92	Title
Drawn	BES	4–93	
Revised	KW	8–94	Title
Checked	AB	8–94	Sheet No 2 of 4

HOME



2" X 8" X 10'-0"
2" X 8" X 16'-0"
END LOCATION RAFTER PLAN DETAIL
INTERIOR LOCATION RAFTERS PLAN DETAIL
2 5/8" Bolts
2" x 4" Purlins (on edge) at 16" o.c. max.
29 ga. Corrugated Sheet Metal
2" x 8" x 16'-0" Rafters @ 8' o.c.
2" X 8" X 10'-0" Rafters @ 8' o.c. (Interior locations only)
(See Details Above)
2 5/8" Bolts
12
3
2" x 8" x 6'- 0"
6" x 6" Post
6" x 6" Post
2" x 4" Cross Brace
For Details of Knee Brace, See Sheet 4 of 4.
6" x 6" Post
10' - 9"
8' - 8"
12' - 0"
Overhang Dependent on Nominal Rafter Length, 1 Foot Minimum.
Top 3 Planks Removable
Support Block
Runner Boards
5" Concrete Slab
Slope 2" in 15'- 6"
6"
12"
Slope 3" in 13'
5" thick concrete slab with 6x6 - W1.4xW1.4 (10 Gage) Wire Mesh Centered in the Slab. See Note 3 below.
See Post Detail
48"
48"
48"
7 3/4"
8' - 6"
5' - 1 1/2"
1'-2 3/4"
15' - 6"
13' - 0"
ELEVATION A - A
Post
Backfill with gravel or concrete
Precast Concrete Footing or equivalent
12" minimum
Post Detail
Not to Scale
NOTES:
1. Provide a construction joint between the composter bin slab and front access slab.
2. A 3" - 6" base course of ODOT # 57 or 67 gravel shall be placed under the concrete slab.
3. Posts shall be separated from the concrete slab with 1/2 inch thick preformed expansion joint material.
COMPOSTING FACILITY, DEAD BIRD
PRODUCER
COUNTY
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STANDARD DRAWING NO.: OH-N-506-CAD
APPROVAL DATE: 07/94
REVISIONS:
Date
Approved by
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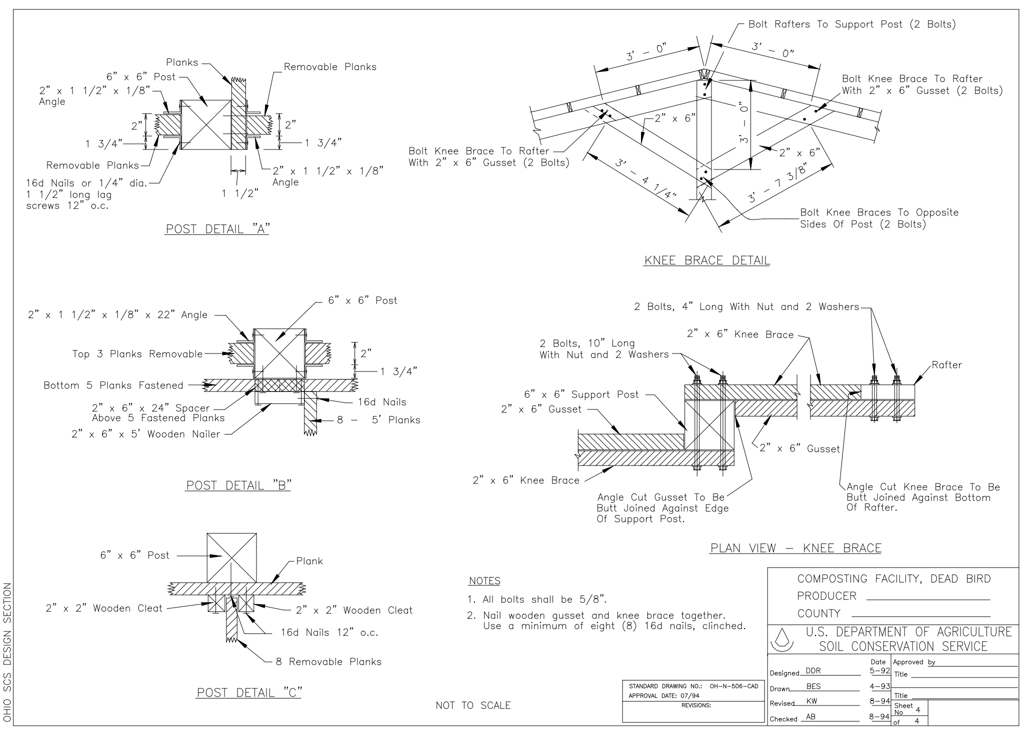
Designed DDR 5-92
Drawn BES 4-93
Revised KW 8-94
Checked AB 8-94
Title
Sheet No. 3 of 4
OHIO SCS DESIGN SECTION



Planks
6" x 6" Post
Removable Planks
2" x 1 1/2" x 1/8" Angle
2"
2"
1 3/4"
1 3/4"
Removable Planks
2" x 1 1/2" x 1/8" Angle
16d Nails or 1/4" dia. 1 1/2" long lag screws 12" o.c.
1 1/2"
POST DETAIL "A"
Bolt Rafters To Support Post (2 Bolts)
3' - 0"
3' - 0"
Bolt Knee Brace To Rafter With 2" x 6" Gusset (2 Bolts)
2" x 6"
3' - 0"
2" x 6"
Bolt Knee Brace To Rafter With 2" x 6" Gusset (2 Bolts)
3' - 4 1/4"
3' - 7 3/8"
Bolt Knee Braces To Opposite Sides Of Post (2 Bolts)
KNEE BRACE DETAIL
6" x 6" Post
2" x 1 1/2" x 1/8" x 22" Angle
Top 3 Planks Removable
2"
1 3/4"
Bottom 5 Planks Fastened
16d Nails
2" x 6" x 24" Spacer Above 5 Fastened Planks
8 - 5' Planks
2" x 6" x 5' Wooden Nailer
POST DETAIL "B"
2 Bolts, 4" Long With Nut and 2 Washers
2" x 6" Knee Brace
2 Bolts, 10" Long With Nut and 2 Washers
Rafter
6" x 6" Support Post
2" x 6" Gusset
2" x 6" Gusset
2" x 6" Knee Brace
Angle Cut Gusset To Be Butt Joined Against Edge Of Support Post.
Angle Cut Knee Brace To Be Butt Joined Against Bottom Of Rafter.
PLAN VIEW - KNEE BRACE
6" x 6" Post
Plank
2" x 2" Wooden Cleat
2" x 2" Wooden Cleat
16d Nails 12" o.c.
8 Removable Planks
POST DETAIL "C"
NOTES
1. All bolts shall be 5/8".
2. Nail wooden gusset and knee brace together. Use a minimum of eight (8) 16d nails, clinched.
NOT TO SCALE
COMPOSTING FACILITY, DEAD BIRD
PRODUCER
COUNTY
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STANDARD DRAWING NO.: OH-N-506-CAD
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Designed DDR 5-92
Drawn BES 4-93
Revised KW 8-94
Checked AB 8-94
Title
Sheet No. 4 of 4
OHIO SCS DESIGN SECTION

APPENDIX B

Ohio EPA's Rule 3745-560-15 of the Ohio Administrative Code

3745-560-15 Composting of dead animals and raw rendering material.

(A) An owner or operator of a class I, class II, or class III composting facility that is composting dead animals or raw rendering material shall comply with the following:

(1) Prior to acceptance of dead animals or raw rendering material:

(a) Designate a person responsible for the day to day operations of the composting facility who has participated in an educational course concerning composting of dead animals and raw rendering material conducted by the Ohio state university extension and who has obtained a certificate of completion for the course. A copy of the certificate shall be made available to Ohio EPA or the approved board of health upon request.

(b) Obtain written concurrence from Ohio EPA upon inspection verifying that the composting facility meets the preparation criteria specified in this chapter.

(2) Dead animals composting. Unless otherwise approved by Ohio EPA or the approved board of health, the owner or operator shall comply with the following when composting dead animals:

(a) Incorporate the dead animals into the composting process upon receipt at the facility.

(b) Document in the log of operations the species of the dead animals accepted and specify the bin where the dead animals were placed.

(c) Conduct the composting in three-sided bins.

(d) Complete the composting of the dead animals in the following stages:

(i) Stage one composting.

(a) The first layer of dead animals shall be placed on top of a bulking agent bottom layer a minimum of eighteen inches thick.

(b) A minimum of six inches of bulking agent shall separate each layer of dead animals.

(c) The last layer of dead animals shall be completely covered with a minimum of twenty-four inches of bulking agent.

(d) A full bin shall remain undisturbed for a minimum of ninety days.

(ii) Stage two composting.

(a) After completion of stage one composting, the contents shall be turned, mixed, or if there is no visible flesh present, moved to a secondary stage bin area and re-covered completely with a minimum of twelve inches of bulking agent.

(b) The material shall remain undisturbed in the secondary stage for a minimum of sixty days.
(c) If at the end of secondary stage there is still visible flesh or non-brittle bones, the owner or operator shall do the following:
(i) Mix with fresh bulking agent as necessary, cover completely with a minimum of twelve inches of bulking agent, and maintain undisturbed for a minimum of sixty days. Parts of dead animals shall not be visible.
(ii) Reintroduce the material in a stage one or stage two bin as part of or in addition to the bulking agents.
(e) If a specific bulking agent or mixing ratio does not enable the composting of the dead animals, re-mix the bulking agent.
(f) Document the bulking agents used and the mixing ratio if applicable in the log of operations.
(3) Raw rendering material composting. Unless otherwise approved by Ohio EPA or the approved board of health, the owner or operator shall comply with the following when composting raw rendering material:
(a) Incorporate the raw rendering material into the composting process upon receipt at the facility.
(b) Document in the log of operations the bin where the raw rendering material was placed.
(c) Conduct the composting in three-sided bins.
(d) Complete the composting of the raw rendering material in the following stages:
(i) Stage one composting.
(a) The first layer of raw rendering material shall be placed on top of a bulking agent bottom layer a minimum of twenty-four inches thick.
(b) A minimum of twelve inches of bulking agent shall separate each layer of raw rendering material.
(c) The last layer of raw rendering material shall be completely covered with a minimum of twenty-four inches of bulking agent.
(d) A full bin shall remain undisturbed for a minimum of ninety days.
(ii) Stage two composting.
(a) After completion of stage one composting, the contents shall be turned, mixed, or if there is no visible flesh present, moved to a secondary stage bin area and re-covered completely with a minimum of twelve inches of bulking agent.
(b) The material shall remain undisturbed in the secondary stage for a minimum of sixty days.
(c) If at the end of secondary stage there is still visible flesh or non-brittle bones, the owner or operator shall do the following:
(i) Mix with fresh bulking agent as necessary, cover completely with a minimum of twelve inches of bulking

agent, and maintain undisturbed for a minimum of sixty days. Parts of the raw rendering material shall not be visible.

(ii) Reintroduce the material in a stage one or stage two bin as part of or in addition to the bulking agents.

(e) If a specific bulking agent or mixing ratio does not enable the composting of the raw rendering material, re-mix the bulking agent in order to achieve an acceptable blend for composting.

(f) Document the bulking agents used and the mixing ratio if applicable in the log of operations.

(4) Compost from dead animals or raw rendering material that does not have visible flesh material or bones shall be utilized on property owned by the owner or operator or tested for distribution in accordance with this chapter.

(5) Request in writing and obtain written concurrence from Ohio EPA or the approved board of health prior to the following:

(a) Utilizing composting systems other than three-sided bins.

(b) Adjusting the thickness of the bulking agent layers.

(c) Adjusting the length of the composting stages.

(d) Adjusting the time frame for incorporation of the dead animals or raw rendering material upon receipt at the facility.

(6) Nuisance. The owner or operator shall conduct operations at the facility in such a manner that dust, odors, and vectors are controlled as to not cause a nuisance.

(a) If odors, dust, or vectors are present, the owner or operator shall apply a cover consisting of a minimum of six inches of biofilter material over the dead animals or raw rendering material not later than twenty-four hours after discovery of the odors, dust, or vectors.

(b) If odors, dust, or vectors persist, then the owner or operator shall upon written notification of Ohio EPA or the approved board of health cease acceptance of dead animals or raw rendering material and dispose of the composting mixture at a licensed solid waste landfill.

(7) Upon written notification that an infectious or contagious animal disease has been reported in the state, the owner or operator shall cease acceptance of the reported dead animals or raw rendering material and dispose of any remaining compost in accordance with all applicable state and federal laws, including any applicable provisions of Chapter 941. of the Revised Code.

(B) Compliance with this rule does not relieve any person of obligations under Chapter 941. or 953. of the Revised Code.

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ACKNOWLEDGMENTS AND RESOURCE ORGANIZATIONS

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Agencies and Organizations for Reference

Ohio Cattlemen's Association	ohiocattle.org	614.873.6736
Ohio Dairy Producers Association	odpa.org	614.890.1800
Ohio Department of Agriculture, Division of Livestock Environmental Permitting	agri.ohio.gov	614.728.6335
Ohio Farm Bureau Federation	ofbf.org	614.249.2400
Ohio Environmental Protection Agency, Division of Materials and Waste Management	epa.ohio.gov/divisions-and-offices/materials-and-waste-management	614.644.2621
Ohio Livestock Coalition	ohiolivestock.org	N/A
Ohio Pork Council	ohiopork.org	N/A
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