Composting to recycle animal tissue nutrients

On-farm mortality management
Small business animal tissue disposal

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Michigan State University
Winter 2007
Animal tissue

Animal production operation

- Normal on-farm mortality
  - Dairy – 2 to 9%
  - Swine – 0.5 to 15%
  - Poultry – 5 to 14%
  - Sheep and goats – 2 to 12%
  - Horse – 1 to 4%
  - Beef – 1 to 3%
Animal tissue

- Animal process operation
  - Butcher shop
  - Slaughter facility
  - Taxidermist
  - Road commission
  - Veterinary clinic
  - Market collection point

MSU Meat Lab

MSU Meat Lab
Bodies of Dead Animals Act

Previously amended:
1982 PA 239 (burial, incineration, landfill, rendering)
1993 PA 228 (to include poultry bin composting)
1998 PA 229 (to include livestock bin composting)

Amended July 7, 2005 Senate Bill No. 2 - Jelinek:
2005 PA 66 (added open pile, windrow, in-vessel and other methods as approved by the director)
Intent of law

- Protect human and animal health
  - Reduce risk of disease transmission.
  - Control flies, vermin, and scavenging animal problems.

- Protect environment
  - Ground and surface water
  - Air quality

Compliance is necessary for Right-to-Farm protection, NPDES General Permit coverage, and MAEAP verification
The law states in Sec. 15. that

... the department shall promulgate rules pursuant to the administrative procedures act of 1969, 1969 PA 306, MCL 24.201 to 24.328

a) The construction and operation of a facility licensed under this act.

b) Vehicles used for the transportation of dead animals.

c) Methodology for active composting to include, but not be limited to, methodology regarding passively aerated static piles, mechanically or forced aerated static piles, windrow piles, and contained or in-vessel systems.
d) Conditions for active composting to include, but not be limited to, recommended conditions regarding moisture content, carbon-to-nitrogen ratio, bulking agent particle size, animal tissue density, composting density, temperature ranges, and pH ranges.

e) Parameters regarding grinding, including, but not limited to, pile form and shape, pile slumping, and the presence of large intact bones after composting.

f) Methods for effluent containment and prevention of its movement into groundwater and surface water.
continuing . . .

d) The accommodation of normal natural daily mortality and system capacity for accommodation of both active composting and curing.

e) Control of odor and pest or vermin infestation of piles with biofilter caps or as otherwise provided by rule.

f) The generation of adequate records involving composting.

g) A system of annual nutrient-content analysis.

h) The final disposition of finished compost.
Animal Compost Rule Making Committee

- Kevin Kirk, Michigan Department of Agriculture
- Jennifer Pickworth, Michigan Department of Agriculture
- Brian Culham, Michigan Department of Environmental Quality
- Anne Woiwode, Sierra Club
- Lynn Henning, Sierra Club
- Duane Roskoskey, Michigan Department of Environmental Quality
- Suzanne Reamer, Natural Resources Conservation Services
- Ernie Birchmeier, Michigan Farm Bureau
- Tonia Ritter, Michigan Farm Bureau
- Gary Trimner, Michigan Milk Producers Association
- Steve Mahoney, Michigan Department of Agriculture
- Dr. Dale Rozeboom, Michigan State University
- Jerrod Sanders, Michigan Department of Environmental Quality
- Rhonda Wuycheck, Michigan Department of Environmental Quality
- Matt Flechter, Michigan Department of Environmental Quality
- Brad Deacon, Michigan Department of Agriculture
Rules: Old and Proposed New

- Normal natural daily mortality intrinsic to an animal operation under common ownership or management.
  - Multiple site farms
- The director may authorize by rule alternative methods of composting of dead animals for emergency, commercial, research, or other applications.
  - Animal processing operations
- Recommended conditions regarding moisture content, carbon-to-nitrogen ratio, bulking agent particle size, animal tissue density, composting density, temperature ranges, and pH ranges.
- Flies, rodents, and vermin are controlled
Rules: Old vs. Proposed New

- Only on-farm mortality of poultry and certain livestock
- Structure – bin w/ floor, walls, roof
  - Structure prevented effluent from leaving
  - Bin size limits for poultry
- Dead animal – means the tissues of mollusks, crustaceans, and vertebrates other than human beings
- Bins (no size limit)
  - Passive static piles, mechanically or forced aerated static piles, windrows, in-vessel
  - Various means to account for all effluent
For an animal production operation accumulating more than 20,000 pounds of mortality annually or any animal process operation, regardless of composting method, composting shall be done in compliance with the following:

- All active, finished, curing, and cured compost at the site shall be located in or on, one or both of the following:
  - On an improved surface as defined by NRCS 313 Waste Storage Facility Conservation Practice Standard, November 2005 (see section on “Liners”) and designed to withstand anticipated loads from the equipment used for placement, aeration and movement of compost.
  - In an in-vessel system.
  - Other methods as approved by the director
All effluent generated and runoff events during active composting and curing, not retained in the compost, shall be managed in a manner consistent with all applicable federal, state, and local laws and with at least one of the following:

- Reintroduced into compost piles
- Collected and stored in a storage facility with a liner meeting the criteria defined in NRCS 313 Waste Storage Facility Conservation Practice Standard, Dated 11/05, and utilized for crop production in accordance with the recommendations in GAAMP’s.
- Diverted to a treatment system meeting the criteria in NRCS 635 Wastewater Treatment Strip Conservation Practice Standard, Date 9/06.
- Other methods as approved by the director
For an animal production operation accumulating less than 20,000 pounds of mortality annually, composting may be done without a structure or vessel provided the following conditions are met:

- A new composting site shall be selected for use annually.
  - Use of the current year’s site may continue until the compost is finished, but not more than 2 years from the time of the first dead animal addition, at which time the finished compost must be disposed of in accordance with Rule 5(10).
  - No new tissue shall be added to a site after one year from the first dead animal addition.
  - May be immediately adjacent to a previous site.
  - A previous site shall not be revisited within a 10-year period of time.
- Shall be on land used in crop production.
- Shall not be directly above subsurface drains (tile).
Rules: Old vs. Proposed New

- **Limited list of bulking agents**
  - Sawdust
  - Chopped straw
  - Spelt hulls
  - Bean pods
  - Grass clippings
  - Leaves
  - Shredded cardboard or newspaper
  - Chopped cornstalks
  - Finished compost

- **More bulking agents, also**
  - Fresh manure
  - Manure with bedding
  - Wasted feed (ground corn, silage, haylage)
  - Legumes (peas, beans, soybeans)
  - Hay
  - Fresh horse manure
  - Horse manure with bedding
  - Shrub and tree trimmings
  - Cornhusks, cobs
  - Wood chips
Rules: Old vs. Proposed New

- **Records**
  - Required continually for poultry and only 2 years for livestock
  - Temperature once per phase for poultry and twice a week for livestock
  - Two phases – primary and secondary

- **Records**
  - Required continually
  - Temperature once per week
  - Minimum of 3 heat cycles
Rules: Old vs. Proposed New

- 43 sub rules for poultry - specific, limiting, sometimes conflicting
  - If carcass >30 lb. grind or chop required
  - Max bin width/length 12 ft
  - Written management plan to director before starting
  - Times (e.g. 2 to 7 d for 1° poultry bins, ≥ 60 d for 1° and 2° livestock bins)
    - Sub rule 27 says move to secondary pile by d 7, sub rule 29 says minimum 21 d
  - Testing for poultry pathogens yearly
  - Nutrient analysis every batch
  - Max depth 5 ft (livestock 6 ft)
  - Max 4 lb./ft3 (Sub rule 18), but sub rule 2 states 2 lb./ft3

- Grinding optional
- Turning based on temperature and activity of compost
  - Management based on pile temperature; active and curing phases
  - Minimum 3 heat cycles
- Testing optional
- Maximum depth 6 ft
Composting

The **controlled** biological decomposition of organic material under (aerobic and anaerobic) conditions . . .

Not just “above ground burial”
Composting

. . . so that storage, handling and land application of compost can be done without adversely affecting the environment or people, and . . . to recycle nutrients.

Natalie Rector, 2002

Ben Darling, 2005
Composting microorganisms

- **Bacteria**
  - Consume organic material - activity
    - Decompose sugars, starches, proteins, fat and some cellulose
  - Both anaerobic (without air) and aerobic (with air)
    - *Actinomyces* spp. - earthy odor

- **Fungi**
  - More cellulose decomposition
Composting activity

- Rapid decomposition into CO₂, water, heat, minerals, and compost (humus)
- Aerobes are thermophilic
  - 120 to 150°F for week or more
- Aerate when activity decreases
  - <100°F for week or more
  - Increasing aerobic activity and temperature again
- Both will subside again
- Repeated heat cycles until “finished”
“Finished” compost

- Dark, humus-like
- No soft tissues
- Little odor
- Bones must be easily crumbled during the mechanical spreading process. If not, then they must be gathered and placed in a new batch of compost for further decomposition.
BODA states

- “shall not create a public or private nuisance or health hazard”
- “minimize the odor impact on neighboring premise”
- “prevent seepage, runoff, and windblown movement”
Curing

- After active composting, further decomposition at slow rate
- Less heat and lower temperatures (range 60 to 100°F).
- Several weeks to as long as a year or more
  - Bones decomposed
- Is not required by law (BODA)
Curing

- Amount of curing (desired mature or stability) depends on intended use of compost
  - Soil amendment
    - Finished or partially cured
      - Monitor temperature
      - Decomposition may not have ceased entirely
  - Plant medium
    - Fully cured
      - Laboratory test
More process management
Best conditions for active composting

- Carbon-to-nitrogen ratio (C:N; on weight basis) between 15:1 to 40:1.
- Moisture content, range of 40 to 60 %.
- Oxygen concentration of greater than 5%
  - Compost density (lbs./yd³), range of 800 to 1200.
- pH, range of 5.5 to 9.0.
- Temperature (degrees Fahrenheit), range of 100 to 150.
Worksheet to optimize conditions - C:N and moisture

**Performance Summary**

<table>
<thead>
<tr>
<th>Category</th>
<th>Constraints</th>
<th>Mix</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Moisture</td>
<td>50 &lt;= Percent Moisture &lt;= 60</td>
<td>60.0</td>
<td>Percent Moisture OK</td>
</tr>
<tr>
<td>Carbon : Nitrogen</td>
<td>15 &lt;= C:N &lt;= 40</td>
<td>15.0</td>
<td>C:N ratio OK</td>
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<tr>
<td>Bulk Density (lbs/yd^3)</td>
<td>Bulk Density = 850</td>
<td>723</td>
<td>Increase bulk density</td>
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<tr>
<td>Water : Carbon</td>
<td>No criteria set</td>
<td>4</td>
<td></td>
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</table>

**Materials Summary**

<table>
<thead>
<tr>
<th>Material</th>
<th>Constraints</th>
<th>Units</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry carcasses</td>
<td>Poultry carcasses = 1000</td>
<td>lbs</td>
<td>Amount OK</td>
</tr>
<tr>
<td>Sawdust</td>
<td>0 &lt;= Sawdust &lt;= 20000</td>
<td>lbs</td>
<td>Amount OK</td>
</tr>
<tr>
<td>Straw</td>
<td>0 &lt;= Straw &lt;= 2000</td>
<td>lbs</td>
<td>Amount OK</td>
</tr>
<tr>
<td>Laying hen litter</td>
<td>0 &lt;= Laying hen litter &lt;= 500</td>
<td>lbs</td>
<td>Amount OK</td>
</tr>
<tr>
<td>Water</td>
<td>0 &lt;= Water &lt;= 20000</td>
<td>lbs</td>
<td>Amount OK</td>
</tr>
<tr>
<td>Empty</td>
<td>lbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empty</td>
<td>lbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empty</td>
<td>lbs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Materials in Compost Mix**

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount in Mix</th>
<th>Moisture</th>
<th>Carbon</th>
<th>Nitrogen</th>
<th>Bulk Density</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Poultry carcasses</td>
<td>1,000.00</td>
<td>65</td>
<td>4.20</td>
<td>0.84</td>
<td>800</td>
<td>0.01</td>
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<tr>
<td>Sawdust</td>
<td>468.80</td>
<td>39</td>
<td>43.92</td>
<td>0.15</td>
<td>410</td>
<td>45.74</td>
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<tr>
<td>Straw</td>
<td>-</td>
<td>12</td>
<td>49.28</td>
<td>0.62</td>
<td>227</td>
<td>-</td>
</tr>
<tr>
<td>Laying hen litter</td>
<td>500.00</td>
<td>69</td>
<td>14.88</td>
<td>2.48</td>
<td>1479</td>
<td>25.00</td>
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<tr>
<td>Water</td>
<td>8.61</td>
<td>100</td>
<td>0.00</td>
<td>0.00</td>
<td>1686</td>
<td>0.51</td>
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<tr>
<td>Empty</td>
<td>-</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0</td>
<td>-</td>
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<td>0</td>
<td>0.00</td>
<td>0.00</td>
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<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0</td>
<td>-</td>
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</table>

Total Cost $ 71.25

January 29, 2007

http://www.canr.msu.edu/dept/ans/community/people/rozeboom_dale.html
Oxygen concentration

- Particle size
  - Varied
  - 0.1 to 2 inches
- Aeration
  - Moving
  - Turning
  - Mixing
Moisture content

- May have to add water
  - Depends on the moisture content of compost
  - Slowly
    - 1 to 2 gal per minute maximum
  - Fresh bulking agents stored uncovered
  - Quit if leaching

- Compost should leave your hand feeling moist, but not be able to squeeze water out of it. Silage like.
Batch

- Initial additions, or loading, of new dead animals and bulking agent limited to a planned time period
  - Rate of mortality
  - An appropriately sized composting facility.

- Batches provide for appropriately timed temperature monitoring, aerating, and utilization
How to compost a dead animal?

- Carcass preparation
  - Chilling or freezing before composting slows or prevents activity
  - Carcasses left whole - necropsy cut speeds composting process
- May compost carcasses of different livestock species together
  - Under common ownership
How to compost a dead animal?

- Base of pile 1 to 2 feet of unused amendment
- Dead animal placed 6” or further from edge of pile
- Layers with minimum of 6” amendment
  - More for carcasses >500 lbs.
- Surround carcass with finished compost 6 to 12 inches on top of carcass
  - 1 to 1 mix with fresh bulking agent
How to compost a dead animal?

- Cover entire pile with 3 to 6” fresh amendment
  - Biofilter – odor, fly, and vermin control
- Maximum pile depth of 6’
- Aerating speeds process, increases heat, controls flies and vermin
  - Two heat cycles currently required (primary and secondary piles)
Reshape after collapse
Composting site selection

- Avoid wet areas; high & dry, well drained soils
- A minimum setback of 200 ft from waters of the state.
- A minimum of 2 ft above the seasonal high water table as defined by NRCS 313 Waste Storage Facility dated 11/05
- A minimum of 200 ft from any well
- A minimum of 200 ft from the nearest non-farm residence
- Divert clean water

- Locate safe distance from buried & overhead utilities
- Consider other farm traffic
- Consider prevailing winds
- Consider aesthetics and landscaping
- Eliminate off-farm vehicle entry
- Proximity to production facilities
- Ensure all weather access
- Maintain suitable access to sawdust storage
Bones
Practically, how long to compost?

<table>
<thead>
<tr>
<th>Mortality Age (months)</th>
<th>&lt;2</th>
<th>3-5</th>
<th>5-8</th>
<th>8-12</th>
<th>12-24</th>
<th>&gt;24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active decomposition (days)</td>
<td>45</td>
<td>90</td>
<td>120</td>
<td>180</td>
<td>270</td>
<td>365</td>
</tr>
</tbody>
</table>

Age more influential than size – maturity of bones and hide . . . remaining in cured compost shall be removed and added to an active compost pile or shall be disposed of under section 21 of Act No. 239 of the Public Acts of 1982
Records

- Start date of each new batch
- Quantity of tissue
- Temperature twice per week
- Turning dates
- Final disposition (method, location, date, estimated volume/wt, sale)
- Nutrient analysis one pile per year
Example record

<table>
<thead>
<tr>
<th>Michigan Livestock Composting Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>City</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Batch</th>
<th>Date</th>
<th>Pounds Added</th>
<th>Temp</th>
<th>Bin Turned</th>
<th>Disposition (include method, location, estimated volume or weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Michigan State University, Department of Animal Science, Swine Extension
Risk of disease

- Nearly all potential bacterial and viral pathogens will be destroyed within 7 days of properly managed compost
  - Animal tissue placed completely in active portion of batch
  - Heat is lethal
    - Heat cycles must be achieved
  - Organic acids and pH of compost is lethal
  - Competition with other microbes is lethal
- Furthermore, most need a living animal as a host
- Prions will not be destroyed
  - BSE, Chronic wasting disease, scrapie
Biosecurity

- **Vehicles and equipment**
  - Maintain cleanliness between production unit and compost pile
  - Separate equipment

- **Scavenging animals, birds and vermin**
  - Maintain adequate cover over carcasses
  - Construct fencing if problems persist
  - Spread finished compost away from the site

- **Personnel**
  - Identify a manager for the pile
Summary: controllable composting variables

- Bulking agent
  - Percent recycled compost
- Moisture
- Particle Size
- Carbon/nitrogen ratio
- O₂
  - Porosity
  - Aeration Schedule
- Retention Time
  - Curing Time
- Pile shape and depth
Size of bin facility, pile, windrow, in-vessel unit

- Mortality rate
- Weight of mortality
- Animal density efficiency coefficient
  - 10 lb./ft$^3$
- Size of equipment
- Composting activity/speed
  - Management intensity
Suggested number of months for well-managed active composting in static batches for the decomposition of all soft tissues

<table>
<thead>
<tr>
<th>Carcass size, lbs.</th>
<th>Number of months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 25</td>
<td>2</td>
</tr>
<tr>
<td>25 to 125</td>
<td>3</td>
</tr>
<tr>
<td>125 to 250</td>
<td>4</td>
</tr>
<tr>
<td>250 to 500</td>
<td>5</td>
</tr>
<tr>
<td>500 to 1000</td>
<td>6</td>
</tr>
<tr>
<td>1000 or more</td>
<td>8</td>
</tr>
</tbody>
</table>
Bin

- Constructed facility
  - Reinforced concrete floors
  - Two or more bins (rot-resistance, strong enough to resist mechanical forces of turning
    - Three sides
  - Roof
  - Pile
    - Static
The compositing bins are designed with floors having a 2% slope toward the back wall and with the back and end walls sealed at the floor-wall interface to retain leachate that may occur.
• 1 rows of 10’ x 13’ bins, 8” concrete walls suggested (If EQIP, then NRCS to specify)
• Need hard surface apron around bins as ground will thaw because of heat of composting in winter and loader movement will be more difficult. Dimensions dependent on turning radius of loader
• Roof alternative - possibly use a tarp that may be rolled back and forth to allow up to 2” of rainfall
# MSU Compost System Sizing Spreadsheet

## Composting Worksheet for Bovine Mortalities in Bins

### Animal Production Phase

<table>
<thead>
<tr>
<th>Item</th>
<th>Cows</th>
<th>Calves</th>
<th>Heifers</th>
<th>Feeder Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>500</td>
<td>200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Days in this production phase</td>
<td>365</td>
<td>150</td>
<td>168</td>
<td>168</td>
</tr>
<tr>
<td>Number of animals per year</td>
<td>500</td>
<td>487</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Percent mortality</td>
<td>0.05</td>
<td>0.12</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Average weight of animals during phase, lb.</td>
<td>1400</td>
<td>110</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Phase - calculated daily mortality (lb/day)</td>
<td>96</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| Total farm mortality daily (lb./day)                                | 113  |        |         |               |
| Desired time to fill primary bin, number of months                  | 1.5  |        |         |               |
| Total farm mortality per time (lb./day x number of months)          | 5107 |        |         |               |
| Desired animal tissue density, lb./ft³                               | 10   |        |         |               |
| Bin volume needed to fill bin in desired time, ft³                  | 511  |        |         |               |
| Length of bin, ft                                                   | 10   |        |         |               |
| Width of bin, ft                                                    | 12   |        |         |               |
| Height of compost material, ft                                      | 5    |        |         |               |
| Volume of bin, ft³                                                  | 513  |        |         |               |
| Number of months active compost occupies a bin                      | 8    |        |         |               |
| Number of composting bins                                           | 6    |        |         |               |
| Number of bulking agent storage bins                                | 1    |        |         |               |

### Total number of bins needed in compost facility: 7

| Composting facility effective volume, ft³                          | 3762 |
| Composting facility area, ft²                                      | 879  |
**Not to scale**

Pull-type windrow turner

Runoff collection ditch

20,000 pounds or more
Individual aerated static piles

Self-propelled windrow turners

Tractor-assisted windrow turners (two-pass)
### MSU Compost System Sizing Spreadsheet

<table>
<thead>
<tr>
<th>Address:</th>
<th>In, Michigan</th>
</tr>
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<tbody>
<tr>
<td>Phone:</td>
<td></td>
</tr>
<tr>
<td>Fax:</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Animal or Animal Tissue Accumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Others</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days per complete turn (all-in to all-in)</td>
<td>365</td>
</tr>
<tr>
<td>Total number of head per year</td>
<td>500</td>
</tr>
<tr>
<td>Percent mortality</td>
<td>0.055</td>
</tr>
<tr>
<td>Average weight of animals during phase, lb.</td>
<td>1400</td>
</tr>
</tbody>
</table>

| Calculated daily mortality, lb./day | 105 |
| Desired time to fill windrow, number of months | 2 |
| Total farm mortality per time (lb./day x number of months) | 6329 |
| Desired animal tissue density, lb./ft³ | 10 |
| Windrow volume needed to fill windrow in desired time, ft³ | 633 |

| Length of windrow | 18 |
| Width of base of windrow | 18 |
| Height of compost material | 8 |
| Volume of windrow, ft³ | 1737 |

| Number of months compost occupies windrow | 8 |
| **Total number of windrows needed in compost facility** | 4 |

| Tractor and bucket working space, ft | 20 |
| Space needed to form and turn windrow | 4014 |

| Total volume of windrows used for composting, ft³ | 7263 |
| Size of pad for windrows, working space between, and around, ft² | 5369 |

Bin = 879 + 400+168 ft² = 1447 ft² of concrete