

USDA  
NATURAL RESOURCES  
CONSERVATION SERVICE  
  
DELAWARE CONSERVATION  
PRACTICE STANDARD  
  
**ANAEROBIC DIGESTER  
CONTROLLED TEMPERATURE**

CODE 366  
(Reported by No.)

**DEFINITION**

A managed temperature waste treatment facility.

**PURPOSES**

To biologically treat waste as a component of a waste management system to:

- Produce biogas and capture for energy.
- Improve air quality.
- Reduce greenhouse gas emissions.
- Reduce pathogens.
- Improve nutrient management.

**CONDITIONS WHERE PRACTICE  
APPLIES**

This practice applies where:

- Biogas production and capture are components of a planned animal waste management system.

- Existing facilities can be modified to the requirements of this standard or for new construction.
- Manure can be collected fresh and delivered to the digester with a total solids (TS) concentration up to 14 percent.
- The operator has the interest and training to monitor and maintain processes or contracts with a consultant to provide these services.

**CONSIDERATIONS**

**Location.** The digester should be located as near the source of manure as practicable and as far from neighboring dwellings or public areas (minimum distance of 300 ft.) as possible. Proper location should also consider slope, distance of manure transmission, vehicle access, wind direction, proximity of streams and flood plains, and visibility. The digester should be located near a suitable site for energy utilization equipment. Short distances for the transmission of biogas through buried pipe are preferable. In determining the location of the waste storage facility, consider elevation and distance from the digester to take advantage of gravity flow.

**Manure Characteristics.** Aged manure can be fed to the digester if properly reconstituted to the digester design total solids content. The biogas yield from aged manure (generally less than 6 months old) is dependent on the biodegradation that has taken place during the storage period. If frozen, little biodegradation will have occurred, whereas manure in a warm, moist state could be significantly degraded.

**Collection/Mix Tank.** A collection/mix tank may be included to accumulate manure, settle foreign material, and pre-treat influent waste to the appropriate total solids concentration. A volume equal to 2 days of manure collection is recommended.

**Digester Design.** A digester operating fluid depth of 8 feet or greater is generally considered more economical for tank design.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

**Gas Collection Cover.** In areas of extreme wind or excessive snow, appropriate structures may be necessary to protect inflatable and floating digester covers from damage.

**Cover Design.** A variety of digester cover designs can be considered to meet the needs of the farm. A secured, flexible membrane cover can be designed for significant storage of biogas, whereas a rigid cover generally has limited storage.

**Gas Utilization.** The most beneficial use of the biogas energy must be investigated and selected. Depending on the design and climate, digesters may require up to 50 percent of the biogas heat value to maintain the design temperature in the winter. Digesters can be heated by hot water from boilers burning biogas or by heat recovery from engines burning biogas for power generation.

**Effluent Tank.** An effluent tank to hold digester effluent for solids separation treatment may be considered due to the potential value of digested separated solids for bedding or soil amendment.

**Visual Screening.** Analyze the visual impact of the digester within the overall landscape context. Screening with vegetative plantings, landforms, or other measures may be implemented to alleviate a negative impact or enhance the view.

This practice has the potential to affect National Register listed cultural resources or eligible (significant) cultural resources. These may include archeological, historic, or traditional cultural properties. Care should be taken to avoid adverse impacts to these resources. Follow NRCS state policy for considering cultural resources during planning.

### **CRITERIA**

#### **Criteria Applicable to All Purposes**

**Laws and Regulations.** Waste treatment facilities must be planned, designed, and constructed to meet all federal, state, and local regulations.

**Manure Characteristics.** This practice is applicable to manure that is collected fresh,

generally less than 7 days old. Manure shall be essentially free of soil, sand, stones, or fibrous bedding material (including clumps of straw), or otherwise processed to remove or reduce such material.

**Total Solids Concentration.** The total solids of manure influent to the digester shall be as required by the digester type and process design. Except for any supplemental feedstocks and non-manure wastewater as described in following sections, water or wastewater, other than that needed for dilution to achieve the design total solids concentration, shall be excluded from the digester.

**Treatment of Supplemental Feedstocks.** Food waste and wastewater from food processing operations may be added as supplemental feedstocks to a digester when the following conditions are satisfied:

1. The digester is designed to treat such wastes, as documented in the Design Data.
2. The digester Operation and Maintenance Plan includes the handling and treatment of such wastes.
3. The farm's nutrient management plan accounts for the nutrient impact of such wastes.
4. The treatment of such wastes meets with all state and local regulations.

**Treatment of Non-manure Wastewater.** Wastewater from farm operations, such as milking parlor wastewater, barn floor wash water, and runoff from silage bunkers, may be added to a digester when the following conditions are satisfied:

1. The digester design has accounted for the use and treatment of such wastewater and included appropriate handling of such wastewater in the operation and maintenance plan.
2. The farm's nutrient management plan accounts for the nutrient impact of such wastewater.

**Safety.** If the digester will create a safety hazard, it shall be fenced and warning signs posted to prevent children and others from using it for purposes other than intended.

The effect of earthquake loads on the digester and biogas system shall be considered and appropriate protective measures incorporated into the design.

Biogas is flammable and highly toxic. The design of the digester and gas components must consider the hazards associated with normal operation and maintenance and provide adequate safety measures.

**Digester Design.** Digesters shall be designed to facilitate anaerobic digestion of animal manure and meet the minimum design and operational requirements below for the type of digester specified. The design documentation shall specify the type of digester and include a process diagram with the following minimum information:

1. Flow rates, influent, and effluent.
2. Design total and volatile solids content of influent and effluent.
3. Digester volume.
4. Retention time.
5. Heating system, control, and monitoring.
6. Methane yield.
7. 12-month energy budget when applicable.
8. Process control and monitoring.

**Plug Flow Digester.** Plug Flow Digesters shall meet the following requirements:

1. For ruminant manure, the total solids concentration of influent shall be 11 to 14 percent. For other manure sources, the total solids concentration shall be 8 to 14 percent.
2. Digester retention time shall be  $\geq 20$  days.
3. Operational temperature shall be mesophilic ( $95^{\circ}\text{F}$  to  $104^{\circ}\text{C}$ ).

4. The length to width ratio of digester flow path shall be between 3.5:1 and 5:1.
5. The ratio of flow path width to fluid depth shall be less than 2.5:1.
6. The shape of the floor and walls shall be uniform to minimize mixing.

**Complete Mix Digester.** Complete Mix Digesters shall meet the following requirements:

1. Total solids concentration of manure influent shall be from 2.5 to 10 percent.
2. Digester retention time shall be  $\geq 17$  days.
3. Operational temperature shall be mesophilic ( $95^{\circ}\text{F}$  to  $104^{\circ}\text{F}$ ).
4. Appropriate mixing devices shall be provided to assure a complete mix process.

**Fixed Film Digester.** Fixed Film Digesters shall meet the following requirements:

1. Total solids concentration of influent shall be  $\leq 5$  percent. For total solids concentration  $\geq 2.5$  percent, the influent particle size shall be  $\leq 0.25$  inch.
2. Digester retention time shall range from 1 to 6 days, depending on waste biodegradability.
3. Operational temperature shall range from  $59^{\circ}\text{F}$  to  $103^{\circ}\text{F}$ .
4. Microbial support material with  $\geq 3$  inch openings.

**Alternative Digesters.** Alternative Digesters shall meet the following requirements:

1. Design of digesters not meeting the listed design and operational criteria or for a type other than that listed in this standard shall be based on the documented design and performance of such existing animal waste digester and certified as such by a registered professional engineer licensed in the state of the proposed installation.

**Digester Vessel Characteristics.** The digester vessel (tank) shall be a corrosion-protected

material or concrete structure, above or below ground, with allowances for entry and exit of manure, heat pipes, and/or other appurtenances. The tank shall be equipped with a suitable cover designed for accumulation and collection of biogas. The tank and internal components shall be designed to facilitate periodic removal of accumulated solids.

Digester vessels shall meet the structural criteria for “Fabricated Structures” in Practice Standard 313, Waste Storage Facility, and the requirements of state and local seismic codes as applicable.

The following additional criteria apply:

1. Design Operating Volume. The digester shall be sized to retain the volume of manure and water at the design total solids concentration for the digester design retention time (days).
2. Configuration. The configuration of the digester tank is specific to the type of digester design and may be square, rectangular, circular, or the shape necessary to most effectively meet specific criteria listed under Digester Design. Tank dividers or flow separators can be utilized to increase efficiency.
3. Location of Inlet and Outlet. The inlet and outlet devices shall be located to facilitate process flow.
4. Inlet. Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage, and prevent gas loss.
5. Outlet. The digester shall be equipped with an outflow device, such as an underflow weir, that will maintain the operating level, maintain a gas seal under the cover, prevent gas loss, and release effluent directly to separation, storage, or other treatment facility.
6. Cover. The digester cover shall be designed for all internal and external loads and shall capture and convey the biogas to a designed gas outlet. The cover system shall be designed to exclude the entrance of air under all operating conditions. Where the

cover is exposed to the weather, the design shall account for environmental conditions for its service life. Precipitation runoff shall be collected and discharged to suitable grassed or otherwise stabilized areas. The digest cover and materials shall meet the requirements of Practice Standard 367, Waste Facility Cover.

**Operating Temperature.** Digesters shall be maintained at internal temperatures appropriate to the digester type and design. The design shall include heat loss calculations to determine insulation, heat exchanger capacity, and energy requirements as appropriate for maintaining the digester operating temperature within acceptable limits.

Mesophilic Digesters – The digester shall be maintained between 95°F – 103°F with an optimum of 100°F and daily fluctuation of digester temperature limited to less than 1°F.

**Operating Level.** The operating level of digesters shall be designed with appropriate freeboard and overflow or automatic shutdown devices to prevent accidental spillage of effluent or discharge into the gas collection system.

**Gas Collection, Transfer, and Control System.** The biogas collection, transfer, and control system shall be designed to convey captured gas from within the digester to gas utilization equipment or devices (flare, boiler, engine, etc.).

1. Gas collection and transfer – Pipes and/or appurtenances shall meet the following:
  - a. The gas collection system within the digester shall be designed to facilitate exclusion of floating debris.
  - b. Pipes and components within the digester shall be securely anchored to prevent displacement from normal forces including loads from accumulated scum.
  - c. Pipes shall be designed for wet biogas. In colder climates, the pipes may need to be insulated to prevent frost buildup.

- d. Pipes shall be constructed to enable all sections to be safely isolated and cleaned as part of routine maintenance.
  - e. Transfer pipes can be buried or installed above ground and must include provisions for drainage of condensate.
2. Gas Control shall meet the following requirements:
- a. Equipment and components shall be conveniently located and sheltered from the elements.
  - b. Equipment and components shall have a service life of not less than 2 years and shall be readily accessible for replacement or repair.
  - c. The size of equipment and connecting pipes shall be based on head loss, cost of energy, cost of components, and manufacturers' recommendations.
  - d. Gas pipes installed within buildings shall be of type approved for combustible gas.
  - e. Where electrical service is required at the control facility, the installation and all electrical wire, fixtures, and equipment shall meet the National Electrical Code and local and state requirements.

**Gas Utilization.** Gas utilization equipment shall be designed and installed in accordance with standard engineering practice and the manufacturer's recommendations. As a minimum, the installation will include a flare to burn off collected gas and a means of maintaining the digester within acceptable operating temperature limits. As a minimum:

1. The flare shall be equipped with automatic ignition and powered by battery/solar or direct connection to electrical service. The flare shall have a minimum capacity equal to the anticipated maximum biogas production.

2. Gas-fired boilers, fuel cells, turbines, and internal combustion engines, when a component of the system, shall be designed for burning biogas directly, in a mix with other fuel, or shall include equipment for removing H<sub>2</sub>S and other contaminants from the biogas.

**Monitoring.** Equipment needed to properly monitor the digester and gas production shall be installed as part of the system. As a minimum the following equipment is required:

1. Temperature sensors and readout device to measure internal temperature of digester.
2. Temperature sensors and readout device to measure inflow and outflow temperature of digester heat exchanger.
3. Gas meter suitable for measuring biogas.

**Safety.** Biogas is a flammable gas. The gas collection, control, and utilization system shall be designed in accordance with standard engineering practice for handling a flammable gas and to prevent undue safety hazards. As a minimum:

1. "Warning Flammable Gas" and "No Smoking" signs shall be posted.
2. Flares shall be grounded or otherwise protected to minimize the chance of lightning strikes.
3. A flame trap device shall be provided in the gas line between the digester and sources of ignition or as recommended by the flame arrester manufacturer.
4. The location of underground gas lines shall be marked with signs to prevent accidental disturbance or rupture. Mark exposed pipe to indicate whether it is a gas line or other.

**Waste Storage Facility.** When a waste storage facility is a component of the waste system, it shall meet the requirements of Practice Standard 313, Waste Storage Facility. The volume of the digester shall not be considered in determining the storage requirement of the waste storage facility, except that the sludge volume can be

reduced by the anticipated percent destruction of total solids.

### **SPECIFICATIONS**

Plans and specifications for this practice shall be prepared in accordance with the previously listed criteria. Plans and specifications shall contain sufficient detail to ensure successful implementation of this practice. Documentation shall be in accordance with the section "Supporting Data and Documentation" in this standard.

### **OPERATION AND MAINTENANCE**

An operation and maintenance (O&M) plan shall be developed and reviewed with the owner prior to construction. The O&M plan shall be consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. The plan shall list operation and maintenance requirements including but not limited to:

1. Proper loading rate of the digester and total solids content of the influent.
2. Proper operating procedures for the digester.
3. Estimates of biogas production, methane content, and potential energy recovery.
4. A description of the planned startup procedures, normal operation, safety issues, and normal maintenance items.
5. Alternative operation procedures in the event of equipment failure.
6. Instructions for safe use or flaring of biogas.
7. Digester and other component maintenance.
8. Troubleshooting guide.
9. Monitoring plan with frequency of measuring and recording digester inflow, operating temperatures, biogas yield, and/or other information as appropriate.

### **SUPPORTING DATA AND DOCUMENTATION**

The following is a list of the minimum data and documentation to be recorded in the case file:

1. Location the practice on the conservation map.
2. Assistance notes. The notes shall include dates of site visits, name or initials of the person who made the visit, specifics as to alternatives discussed, decisions made, and by whom.

### **Field Data and Survey Notes**

The following is a list of the minimum data needed:

1. Plan view sketch.
2. Soil borings with depth to water table identified.
3. Type, size, and number of animals the structure is designed to serve.
4. Topographic survey as needed for the siting of the structure and its appurtenances.
5. Profile and cross-section of the site if a grading plan is needed.

### **Design Data**

Record on appropriate engineering paper. For guidance on the preparation of engineering plans see Chapter 5 of the Engineering Field Handbook - Part 650. The following is a list of the minimum required design data:

1. Determine soil type and any special restrictions.
2. Determine the type of digester that will be constructed.
3. Design the digester in accordance with this Practice Standard or by other approved methods.
4. Include the Miss Utility notification statement.

5. Show job class on the plan.
6. Layout and location of livestock facilities, waste collection points, waste transfer pipe, digester, biogas utilization facilities, and digester effluent storage.
7. Grading plan showing excavation, fill, and drainage, as appropriate.
8. Materials and structural details of the digester, including all premixing tanks, inlets, outlets, pipes, pumps, valves, and appurtenances as appropriate to the complete system.
9. Maximum and minimum operating levels (elevations).
10. Structural details of all components with dimensions and special requirements noted.
11. Details of gas collection, control, and utilization system including type of materials for pipe, valves, regulators, pressure gages, electrical power, and interface as appropriate, flowmeters, flare, utilization equipment, and associated appurtenances.
12. A process flow diagram.
13. Special safety requirements.
14. Seeding, fertilizing, and mulching requirements.

#### **Utilities Notification**

1. Forms ENG-5 and ENG-6 can be used to assist in tracking utility notifications.
2. Document on CPA-6 initial discussion about his or her responsibility to notify Miss Utility.
3. Document on CPA-6 any information from the landowner about the existence and location of known utilities.
4. Document on CPA-6 assurances from the landowner that Miss Utility has been notified, including staking by the utilities.

#### **Construction Check Data/As-Built Plans**

Record on survey notepaper, NRCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted in red on the as-built plans. Document approval by the designer of any changes from the drawings or specifications before implementation of the change.

The following is a list of minimum data needed for as-built documentation:

1. Documentation of site visits on CPA-6. The documentation shall include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom.
2. Check notes recorded during or after completion of construction showing dimensions and elevations of the structure, as appropriate.
3. Statement on seeding and fencing.
4. Final quantities and documentation for quantity changes. Material certifications as appropriate.
5. Sign and date check notes and plans by someone with appropriate approval authority. Include statement that practice meets or exceeds plans and NRCS practice standards.