NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

ANAEROBIC DIGESTER - CONTROLLED TEMPERATURE

(No.)

CODE 366

DEFINITION

A managed temperature waste treatment facility.

PURPOSE

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.

CRITERIA

General 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 the 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:

- The digester is designed to treat such wastes as documented in the plans and specifications.
- The digester operation and maintenance plan includes the handling and treatment of such wastes.
- The farm's nutrient management plan accounts for the nutrient impact of such wastes.
- 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:

- 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.
- 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 shall be 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:

- Flow rates, influent, and effluent
- Design total and volatile solids content of influent and effluent
- Digester volume
- Retention time
- Heating system, control, and monitoring
- Methane yield
- 12-month energy budget when applicable
- Process control and monitoring

Digester types

- Plug flow digester
  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 > 20 days.
  3. Operational temperature shall be mesophilic (35º to 40º C, 95º to 103º F).
  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
  1. Total solids concentration of manure influent shall be from 2.5 to 10 percent.
  2. Digester retention time shall be > 17 days.
  3. Operational temperature shall be mesophilic (35º to 40º C, 95º to 103º F).
  4. Appropriate mixing devices shall be provided to assure a complete mix process.
- Fixed film digester
  1. Total solids concentration of influent shall be ≤ 5 percent. For total solids concentration ≥ 2.5 percent, the influent particle size shall be ≤ 0.25 inch.
  2. Digester retention time shall range from 1 to 6 days, depending on waste biodegradability.
  3. Operational temperature shall range from 15º to 40º C (59º to 103º F).
  4. Support the microbial material with ≥ 3 inch openings.

Alternative digester design criteria

Design of digesters not meeting the listed design and operational criteria or for a type not 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 Conservation Practice Standard 313, Waste Storage Facility, and the requirements of state and local seismic codes as applicable.

The following additional criteria applies:

- **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).
- **Configuration.** The configuration of the digester tank is specific to the type of digester design and may be square, rectangular, circular, or as necessary to most effectively meet specific criteria listed under Digester Design. Tank dividers or flow separators can be utilized to increase efficiency.
- **Location of inlet and outlet.** The inlet and outlet devices shall be located to facilitate process flow.
- **Inlet.** Inlets shall be of any permanent type designed to resist corrosion, plugging, and freeze damage and to prevent gas loss.
- **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.
- **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.

  Covers shall meet the requirements of Conservation 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 35º C (95º F) and 40º C 103º F) with an optimum of 37.5º C (100º F) and daily fluctuation of digester temperature limited to less than 0.55º C (1º 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.).

- **Gas collection and transfer.** Pipe and/or appurtenances shall meet the following:
  1. The gas collection system within the digester shall be designed to facilitate exclusion of floating debris.
  2. Pipe and components within the digester shall be securely anchored to prevent displacement from normal forces including loads from accumulated scum.
  3. Pipe shall be designed for wet biogas. In colder climates, the pipe may need to be insulated to prevent frost buildup.
  4. Pipes shall be constructed to enable all sections to be safely isolated and cleaned as part of routine maintenance.
  5. Transfer pipe can be buried or installed above ground and must include provisions for drainage of condensate.

- **Gas control**
  1. Equipment and components shall be conveniently located and sheltered from the elements.
  2. Equipment and components shall have a service life of not less than 2 years and shall be readily accessible for replacement or repair.
  3. The size of equipment and connecting pipe shall be based on head loss, cost of energy, cost of components, and manufacturers' recommendations.
  4. Gas pipe installed within buildings shall be of type approved for combustible gas.
  5. 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.

- 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.
- 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_2S 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:

- Temperature sensors and readout device to measure internal temperature of digester
- Temperature sensors and readout device to measure inflow and outflow temperature of digester heat exchanger
- 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, there shall be the following:

- “Warning Flammable Gas” and “No Smoking” signs shall be posted.
- Flares shall be grounded or otherwise protected to minimize the chance of lightening strikes.
- 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.
- The location of underground gas lines shall be marked with signs to prevent accidental disturbance or rupture. Mark exposed pipe to indicate whether 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 Conservation 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.

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 91 meters [300 feet]) 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.

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 or viewshed. Screening with vegetative plantings, landforms, or other measures may be implemented to alleviate a negative impact or enhance the view.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and sound engineering practice, and shall describe the requirements for applying this practice to achieve its intended use.

As a minimum, the plans and specifications shall provide the following:

- Layout and location of livestock facilities, waste collection points, waste transfer pipe, digester, biogas utilization facilities, and digester effluent storage
- Grading plan showing excavation, fill, and drainage, as appropriate
- Materials and structural details of the digester, including all premixing tanks, inlets, outlets, pipes, pumps, valves, and appurtenances as appropriate to the complete system
- 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
- A process flow diagram

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. The plan shall contain operation and maintenance requirements including but not limited to:

- Proper loading rate of the digester and total solids content of the influent
- Proper operating procedures for the digester
- Estimates of biogas production, methane content, and potential energy recovery
- Description of the planned startup procedures, normal operation, safety issues, and normal maintenance items
- Alternative operation procedures in the event of equipment failure
- Instructions for safe use or flaring of biogas

- Digester and other component maintenance
- Troubleshooting guide
- Monitoring plan with frequency of measuring and recording digester inflow, operating temperatures, biogas yield, and/or other information as appropriate