Anaerobic Digester (No.) 366

DEFINITION

A component of a waste management system that provides biological treatment in the absence of oxygen.

PURPOSE

For the treatment of manure and other byproducts of animal agricultural operations for one or more of the following reasons to

- *Capture biogas for energy production*
- *Manage odors*
- *Reduce the net effect of greenhouse gas emissions*
- *Reduce pathogens*

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Biogas production and capture are components of a comprehensive nutrient management plan or planned animal waste *and byproduct(s)* management system.
- *Sufficient and suitable organic feedstocks are readily available.*
- Existing facilities can be modified to the requirements of this standard or for new construction.

THE OPERATOR HAS THE INTEREST, TRAINING *AND SKILLS* TO MONITOR AND MAINTAIN PROCESSES OR CONTRACTS WITH A CONSULTANT TO PROVIDE THESE SERVICES.

CRITERIA

General Criteria Applicable To All Purposes

Laws and Regulations. *Anaerobic Digester facility* must be planned, designed, and constructed to meet all Federal, State, local, and tribal regulations.

Air Pollution Control. Air Pollution Control Rules have been adopted in Michigan pursuant to Part 55, Air Pollution Control, of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451). The digester owner must apply to the Michigan Department of Environmental Quality (MDEQ) for a permit to install unless it can be demonstrated that the digester "activity" is eligible for an exemption pursuant to rules 336.1278-336.1290. Consultation with MDEQ Air Quality Division is required to determine permits required or exemption eligibility.

Digester containment (tanks) shall meet the isolation distance requirements for drinking water wells as described in the Location section of NRCS Practice Standard 313, Waste Storage Facility.

***Feedstock* Characteristics.** The design of the digester needs to take feedstock properties into account. Extraneous material such as soil, sand, stones or fibrous bedding material (including clumps of straw*), must be ground, removed, reduced, or otherwise handled.*

The total solids of *feedstock* influent to the digester shall be as required by the digester type and process design. Water or wastewater, other than that needed for dilution to achieve the design total solids concentration, shall be excluded from the digester.

Food waste and wastewater from food processing operations *and other allowable organic substrates* 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 Plans and Specifications.
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 *feedstock will comply* with all State and local regulations.

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

Biogas is flammable, highly toxic *and potentially explosive.* The design of the digester and gas components *including the gas collection, control, and utilization system,* must consider the hazards

associated with normal operation and maintenance, provide adequate safety measures *including appropriate earthquake loads, and shall be in accordance with standard engineering practice for handling a flammable gas and to prevent undue safety hazards. As a minimum:*

- *"Warning Flammable Gas" and "No Smoking" signs shall be posted.*
- *Appropriate fire protection equipment and biogas leak detection sensors, especially in confined areas shall be provided.*
- *Flares shall be located an appropriate distance from biogas sources. Enclosed flares shall be located as recommended by the manufacturer. Open flares shall be located a minimum distance of 95 feet from the biogas source. The flares shall have a minimum height of 10 ft and shall be grounded or otherwise protected to minimize the chance of lightning strikes.*
- *A flame trap device shall be provided in the biogas 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 it is a gas line or other line.*

Digester Design. Digesters shall be designed to facilitate anaerobic digestion of animal manure and *other byproducts of animal agricultural operations to* 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.

Digester Types

Plug Flow Digester

1. The total solids concentration of influent shall be 11-14 percent.
2. Digester retention time shall be *a minimum of* 20 days.
3. Operational temperature shall be mesophilic *(ranging from* 95-104ºF or35-40ºC.
4. The length to width ratio of digester flow path shall be *a minimum of* 3.5:1.
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 *facilitate the movement of all material through the digester to minimize short-circuiting flow*.

Complete Mix Digester

1. Total solids concentration of manure influent shall be *less than 11* percent.
2. Digester retention time shall be a *minimum of* 17 days.
3. Operational temperature shall be mesophilic ranging from 95-104ºF or 35-40ºC.
4. Appropriate devices shall be provided, *as necessary,* to assure a *continuous flowing and* mixing process.

Alternative Type Digester

Types of digesters not meeting the above criteria or for a type other than listed in this standard (such as fixed film, induced blanket, or thermophilic reactors) 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 *Containment* Characteristics.

1. Design tanks and *internal components (including heat* pipes and other *appurtenances) to facilitate periodic*

removal of accumulated solids and for corrosion protection.

2. *Tanks 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:

- Design Operating Volume. Size *the digester* to retain the volume of manure and water at the design *hydraulic and* solids 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.
- Inlet and Outlet. Locate the inlet and outlet devices to facilitate process flow. Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage, and prevent gas loss. Equip the digester 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. Covers 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 NRCS Practice Standard 367, Waste Facility Cover.

- *Heating system. Heating system shall be designed and installed with consideration for minimizing corrosive attack and scalding build-up on the heating surfaces.*
- 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.
- 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. Design the biogas collection, transfer, and control system to convey captured gas from within the digester to gas utilization equipment or devices (flare, boiler, engine, etc.).

1. Gas collection and transfer - Pipe and/or appurtenances shall meet the following:
   - Design the gas collection system within the digester to *minimize plugging.*
   - Securely anchor *pipe and components within the digester* to prevent displacement from normal forces, including loads from accumulated scum.
   - Design *the collection and transfer pipe* for wet biogas. In colder climates, *protect* the pipe as necessary to prevent frost buildup. The pipe size shall be no less than 3-inch diameter, unless a detailed design is performed to account for frost buildup and pressure drop in a low-pressure system. Pressurized systems shall be designed as an Alternative Type Digester.
   - Gas pipe installed within buildings shall be of type approved for combustible gas.
   - Pipe *used for transfer of gas must include provisions for drainage of condensate, pressure and vacuum relief, and flame traps.*
   - *Pipes shall* be *installed to* enable all sections to be safely isolated and cleaned as part of routine maintenance.

- Steel pipe shall meet the requirements of AWWA Specification C-200 or ASTM A53/A211 for stainless steel.
- Plastic pipe shall meet the requirements of AWWA Specification C-906 or ASTM D-3350 for HDPE.

2. Gas Control

- Equipment and components shall be conveniently located and sheltered from the elements.
- Equipment and components shall have a service life of not less than 2 years and shall be readily accessible for replacement or repair.
- The size of equipment and connecting pipe shall be based on head loss, cost of energy, cost of components, and manufacturers' recommendations.
- 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. Design and install *gas utilization equipment* in accordance with standard engineering practice and the manufacturers' 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.

- Equip *the flare* with automatic ignition and powered by battery/solar or direct connection to electrical service. The flare shall have a capacity equal to *or greater than* the anticipated maximum biogas production. *Install a windshield to protect an open flare against wind.*
- 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.
- *Install and maintain a gas meter, suitable for measuring biogas.*

Monitoring *for mesophilic digesters.* *Install* equipment needed to properly monitor the digester and gas production 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.

Waste Storage Facility. When a waste storage facility is a component of the waste system, it shall meet the requirements of NRCS 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 volume can be reduced by the anticipated percent destruction of total solids.

CONSIDERATIONS

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

Consider the potential effects of installation and operation of the digester on the cultural, archeological, historic, and economic resources.

Manure Characteristics. *Fresh manure has the most energy content; however,* 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 manure is frozen, little biodegradation will have occurred, whereas manure in a warm, moist state could be significantly degraded *and biogas production will be substantially reduced. Also, consider potential inhibitory effects of any antimicrobial agents in the manure or waste stream.*

Collection/Mix Tank. A collection/mix tank may be included to accumulate manure, settle foreign material, pre-*heat, and/or pre-treat* influent waste to

the appropriate total solids concentration. A volume *of 1 to 3* days of manure collection*, depending on the planned system management,* is often used.

Overflow Protection. Consider designing the transfer system with the capability to bypass the digester, going directly to storage or land application equipment in case of equipment failure.

Digester Type. The type of digester selected may be affected by geographical location (figure 1) energy considerations, wastewater properties, and other design considerations (figure 2).

Digester Design. A digester operating fluid depth of 8 feet or greater is usually more economical for tank design. *Tank dividers or flow separators may be utilized to increase efficiency and prevent short-circuiting. Interior slopes should be as steep as permitted by soil properties and construction techniques.*

Grounding and Cathodic Protection. *Stray voltage, electrolysis and galvanic corrosion can damage pipes inside digesters. Consider the design requirements for electrodes and anodes.*

Electrical Component Protection. *Very small concentrations of biogas can corrode electrical hardware. Consider locating electrical controls in a separate room or building away from the digester and generator.*

Temperature Maintenance. *The design should include a means of maintaining the digester within acceptable operating temperature limits, where appropriate.*

Gas Transfer Pipe. *Exposed pipe conveying flammable gas is generally painted yellow, per IAW ASME A13.1-1996.*

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.

Air Quality. Recovering energy from the biogas may be a preferable alternative to flaring. This could reduce fossil fuel combustion and associated emissions, thereby reducing the net effect of greenhouse gases and improving air quality.

Gas Utilization. The most beneficial use of the biogas energy should be investigated and selected. Sales of carbon credits may affect the manner of *utilization.* Depending on the design and climate, digesters may require *more than* 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 *internal combustion* engines *and micro turbines* burning biogas for power generation.

Effluent Tank. An effluent tank to hold digester effluent for *subsequent mechanical* solid-*liquid* separation may be considered due to the potential *use* of digested separated solids for bedding or soil amendment.

***Siting and Vegetation*.** Analyze the visual impact of the digester within the overall landscape context *and effects on aesthetics.* Screening with vegetative plantings, *landscaping*, or other measures may be implemented to alleviate a negative impact or enhance the view. *In addition, disturbed areas should be vegetated as soon as possible.*

Soil Properties. *Soil properties such as texture, K_{sat}, flooding, slope, water table and depth, as well as limitations related to seepage, corrosivity, or packing of soil material should be considered when designing storage structures. Refer to local soil survey information and on-site soil investigations during planning.*

Nutrient Availability. *Consider the effects of digestion upon nutrient availability. Land applications of digester effluent, compared with fresh manure, may have a higher risk for both ground and surface water quality problems. Compounds such as nitrogen, phosphorus and other elements become more soluble due to anaerobic digestion and therefore have higher potential to move with water.*

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 the practice to achieve its intended use.

Support data documentation requirements are as follows:

- Inventory and evaluation records
  - Conservation Assistance notes or special report
- Survey notes, where applicable
  - Design survey
  - Construction layout survey

- Construction check survey
- Design records
  - Physical data, functional requirements, and site constraints, where applicable
  - Soils/subsurface investigation report, where applicable
- Design and quantity calculations
- *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 biogas collection, control, and utilization system including type of materials for pipe, valves, regulators, pressure gages, electrical power and interface as appropriate, flow meters, flare utilization equipment, and associated appurtenances.*
- *Specify insulation, heat exchanger capacity, and energy requirements as appropriate for maintaining the digester operating temperature within acceptable limits.*
- *A process flow diagram with the following:*
  - *Flow rates of influent, effluent, and biogas*
  - *Design total and volatile solids content of influent and effluent.*
  - *Digester volume.*
  - *Hydraulic and solids retention times.*
  - *Heating system type and capacity, control, and monitoring.*
  - *Biogas production, including methane yield.*
  - *12-month energy budget when applicable.*
- Construction drawings/specifications with:
  - Location map
  - "Designed by" and "Checked by" names or initials
  - Approval signature
  - Job class designation
  - Initials from preconstruction conference
  - As-built notes
- Construction inspection records
  - Conservation Assistance notes or separate inspection records
  - Construction approval signature
- Record of any variances approved, where applicable
- Record of approvals of in-field changes affecting function and/or job class, where applicable
- Layout and location of livestock facilities, waste collection points, waste transfer pipe, digester, biogas utilization facilities, and digester effluent storage

OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan shall be developed for this practice. The O&M plan shall be consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for the design.

Figure 1. Heated digester systems are required above the 40th parallel.

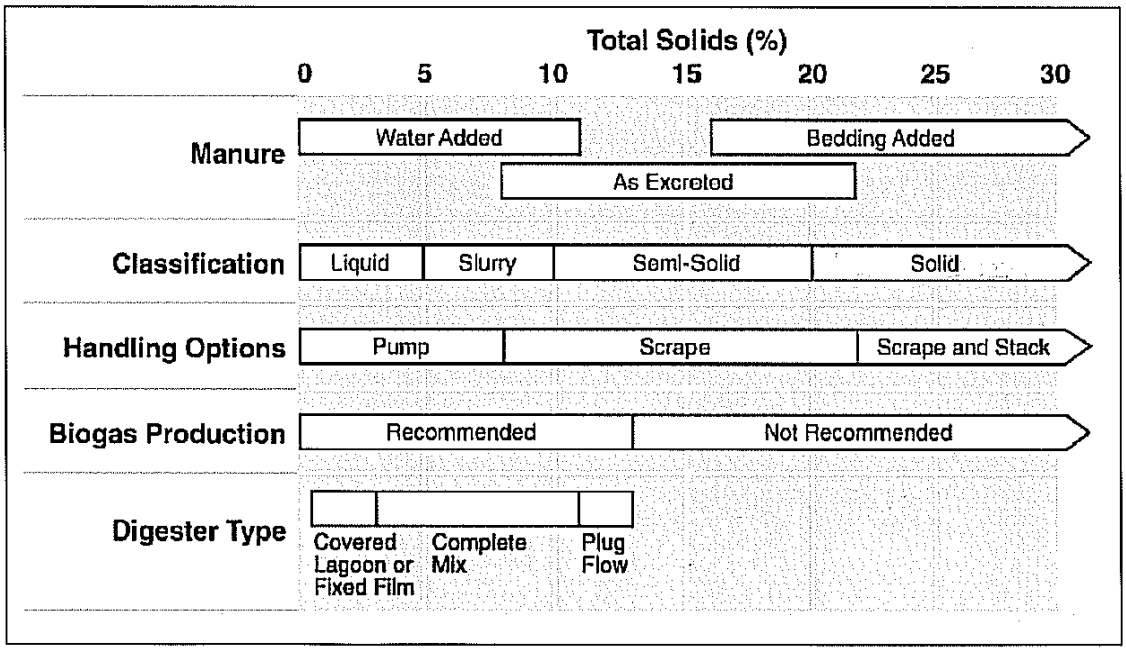

Figure 2. The type of digester selected is affected by multiple parameters and subject to specific design considerations (US EPA – AgStar).