Appendix F National Resource Conservation Service Practice Standards

Contents:

Each state determines which national conversation practice standards are applicable in their state. States often add technical criteria and issue them as state conservation practice standards. You should consult with the state to ensure that you meet all state and local standards, which may be more restrictive than national standards. To find your state office or review these practice standards on line, please visit www.nrcs.usda.gov.

Appendix F National Resource Conservation Service Practice Standards

ANAEROBIC DIGESTER – AMBIENT TEMPERATURE

(No.)

Code 365

DEFINITION

An unheated waste treatment impoundment.

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

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Biogas production and capture are components of a planned animal waste management system. Suitable geographic areas for energy recovery are shown in Figure F-1.
- Existing waste impoundment(s) can be modified to the requirements of this standard or for new construction.
- The digester is in conjunction with a separate waste storage facility or where the digester and storage are congruent.
- Manure can be collected fresh and delivered to the digester with a total solids (TS) concentration in the influent waste of less than 2 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 processed to remove such material.

Ruminant's manure shall be treated with solid separation prior to entry into the digester.

Rainfall Runoff. Rainfall runoff shall be diverted away from the digester.

Anaerobic Digester. The digester shall meet the General Criteria for All Lagoons given in Practice Standard 359, Waste Treatment Lagoon, as appropriate, and the following additional requirements:

1. Minimum Treatment (Design Operating) Volume. The design operating volume shall be based either on the daily volatile solids (VS) loading rate per 1,000 ft^3 or the minimum hydraulic retention time (HRT) adequate for methane production, whichever is greater. The maximum daily VS loading rate shall be selected from the values listed on the map in Figure F-2. The minimum HRT shall be selected from values listed on the map in Figure F-3.
2. Required Total Volume. The required total volume of the digester shall be equal to the minimum treatment volume except where waste storage is included in the design, in which case the volume shall meet the additional criteria for Design Storage Volume in Practice Standard 313, Waste Storage Facility, as appropriate.

The digester storage volume does not need to account for rainfall except for partially covered digesters.

3. A minimum of 2 feet of freeboard above the digester design water surface shall be provided except when rainfall is included in determining the operating volume, where only 1 foot of freeboard is required.
4. Length to Width Ratio. The ratio of length to width of the digester is limited to 4:1 or less.
5. Operating Depth. The operating depth of the digester shall be at least 12 feet over 50 percent or more of the bottom area.
6. Interior Slopes. Interior slopes shall be as steep as permitted by soil properties and construction techniques.
7. Waste Inlet and Outlet. The inlet and outlet devices shall be located as far apart as practical to minimize "short circuiting."
8. The inlet shall discharge a minimum of 12 inches below the digester water surface.
9. Outlet. The digester shall be equipped with an outflow device that maintains the digester water surface at its operating level. Except where the digester is designed to include storage, the outlet shall release directly to the waste storage facility without release of trapped gas.
10. Digester Cover. The digester cover, materials, anchorage, and all appurtenances, such as weights and floats, shall be designed to capture and convey biogas to the gas collection system. The digester cover and materials shall meet the requirements of Practice Standard 367, Waste Facility Cover.

Separate Waste Storage Facility. Separate waste storage facilities shall meet the requirements of Practice Standard 313, Waste Storage Facility. No storage credit shall be attributed to the digester in meeting the minimum storage requirements in Practice Standard 313 except for sludge volume reduction based on expected total solids (TS) removed or destroyed.

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

Gas Collection and Transfer

1) Perforated pipe and other components under the digester cover shall be designed to exclude floating debris and waste residue and shall have a service life consistent with the expected cover life, but not less than 10 years.

2) Pipe and components under the cover shall be securely anchored to prevent displacement from normal cover forces.

3) The collection and transfer pipe shall be designed for wet biogas. In colder climates, the pipe shall be protected as necessary to prevent frost buildup. In no case shall the pipe size be less than 3-inch diameter.

4) Pipe used for transfer of gas can be buried or installed above ground and must include provisions for drainage of condensate, pressure and vacuum relief, and flame traps.

Gas Control

1) Gas control equipment and components shall be conveniently located and sheltered from the elements. A minimum distance of 30 feet (10 m) shall separate the control facility from the digester.

2) Gas control 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) 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

recommendations. As a minimum, the installation will include a flare to burn off collected gas.

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, turbines, and internal combustion engines, when a component of the system, shall be designed for burning biogas directly or shall include equipment for removing H_2S and other contaminants from the biogas.

Monitoring. When the purpose is to produce and capture biogas for energy, 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:

- A temperature sensor and readout device to measure internal temperature of digester.
- Gas meter suitable for measuring biogas.

Safety. Methane is a flammable gas. The gas collection, control, and utilization system shall be designed to incorporate measures to prevent undue safety hazards. As a minimum, "Warning Flammable Gas" and "No Smoking" signs shall be posted.

Flares shall be located a minimum distance of 95 feet (30 m) from the biogas source and 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 points of use (flare, boiler, engine, etc.).

The location of underground gas pipe shall be marked with signs to prevent accidental disturbance or rupture. Mark exposed pipe to indicate whether gas line or other.

CONSIDERATIONS

Location. In determining the location of the waste storage facility, consider elevation and distance from the covered digester to take advantage of gravity flow.

The covered 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 (100 m)) as possible. Proper location should consider slope, distance of manure transmission, vehicle access, wind direction, neighboring dwellings, proximity of streams and flood plains, and visibility.

Using available gas to heat the digester can improve total solids destruction and further reduce greenhouse gas emissions. In geographic areas north of the 40th parallel (Figure F-1), heat is required to maintain year around anaerobic digestion.

The covered digester should be located near a suitable site for energy utilization equipment. Short distances for the transmission of methane through buried pipe are preferable.

Waste Transfer Pipe. The standard practice is to locate a cleanout immediately upstream of the digester. Influent from the waste collection pit discharges below the digester operating level, and depending on the installation, solids tend to build up in the inlet pipe. The cleanout is also a good location for venting any gas that builds up in the transfer pipe.

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.

Depth of Digester. Improved digester performance and reduced cover cost (less area for given volume) can be realized with deeper digesters.

Rainfall. Rainfall on the digester cover can result in increased effluent discharge into the storage facility. For normal rainfall events this is probably not a problem. In locations subject to high rainfall events (thunderstorms and hurricanes), a ported riser on the outflow pipe should be considered to provide temporary storage and reduce outflow rate.

Gas Transfer Pipe. Exposed pipe conveying flammable gas is generally painted orange.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and good engineering practice. The plans and specifications shall include all details necessary for construction and completion of the work.

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

1. Layout of livestock facilities, waste collection points, waste transfer pipe, digester, and storage pond.
2. Location of all digester influent pipes and devices.
3. Details of pipe material, size, and grade.
4. All digester and storage pond dimensions, type of lining material, and other parameters as appropriate.
5. Digester cover material and dimensions of covered surface. Means of rainfall removal or details of drainage.
6. Details of digester cover anchorage (ex: location and width of trench, depth, backfill material, and compaction of fill).
7. Details of the gas collection system, including type of pipe, devices, sizes, location, material, and grades.
8. Details of gas control facility, piping layout, components, electrical service if required, and protection from the elements.
9. Appropriate gas safety equipment or protective measures.

Warranties. The cover manufacturer and/or installer shall warrant the cover for the intended use and design life, provide maintenance instructions, and certify that the cover is properly installed.

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 influent.
2. Proper operating level of 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 and/or flaring of biogas.
7. Cover and gas collection system maintenance.
8. Daily inspection of the following:

   - Cover material – check for cracks, tears, or points of distress around perimeter.

   - Check for excessive ballooning of cover or presence of odor.

   - Check for excess rainwater on cover.

   - Check gas control panel, regulators, pressure gages, electrical power, flowmeter, flare igniter, and flare operation.

9. Frequency of measuring and recording digester inflow, operating temperatures, biogas yield, and/or other information as appropriate.

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Figure F-1. Locations suitable for energy production with an ambient temperature digester generally fall below the 40th parallel.

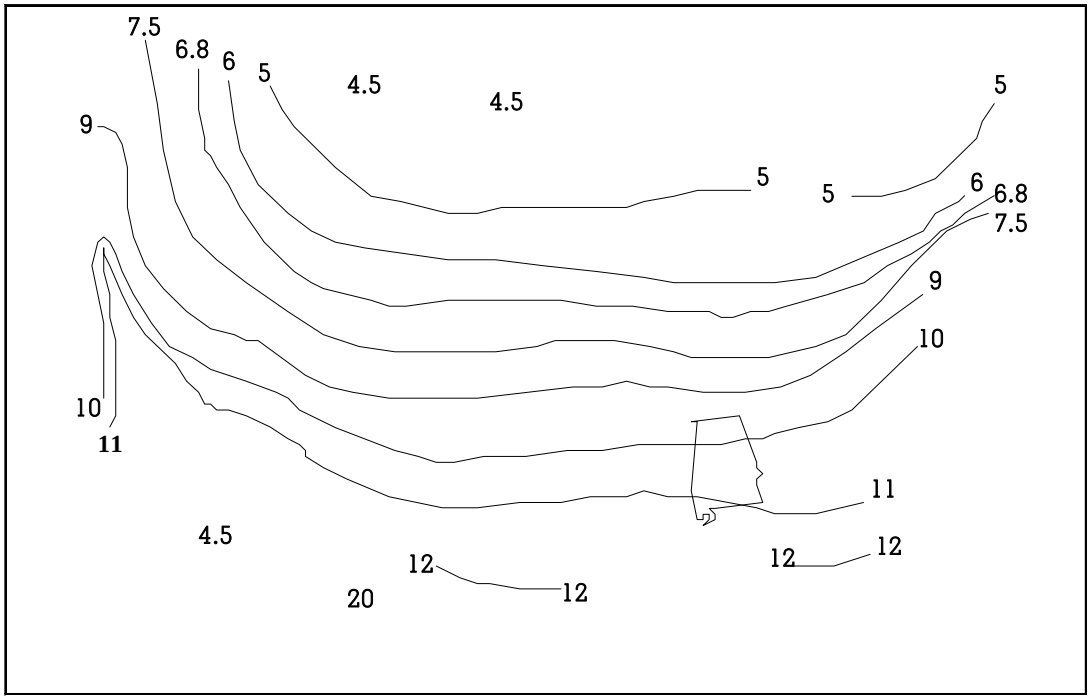

Figure F-2.
Covered anaerobic digester maximum loading rate (lb VS/1,000 ft^3/day)

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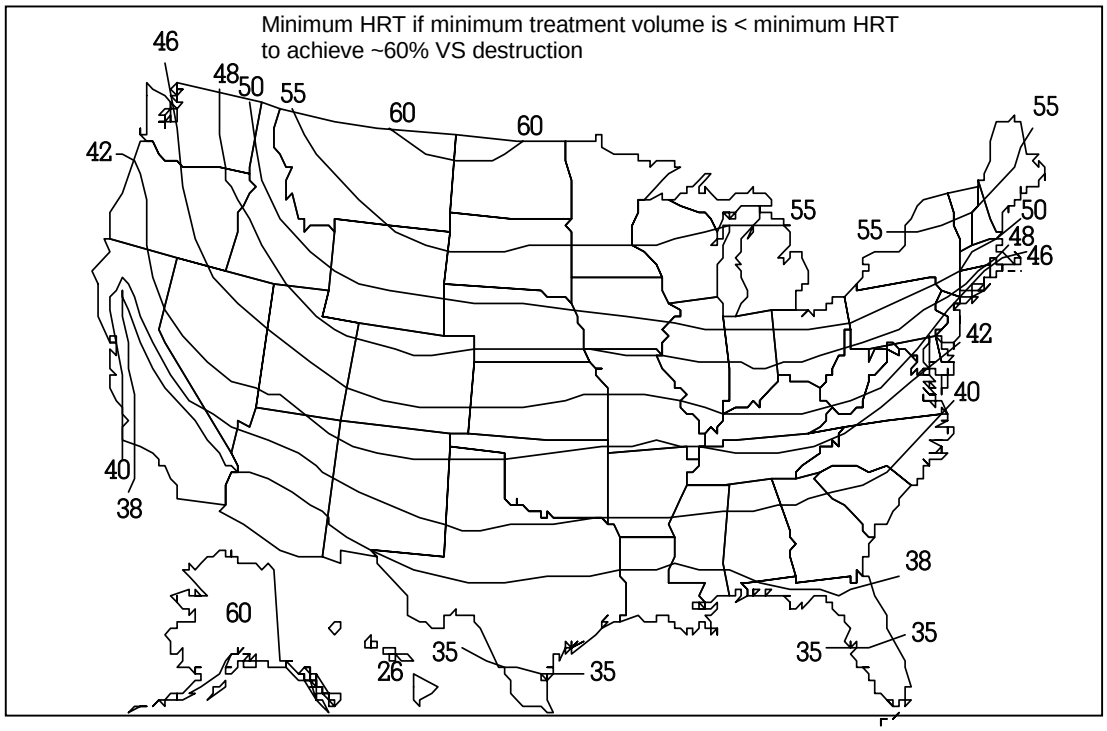

Figure F-3. Covered anaerobic digester minimum hydraulic retention times (MINHRT) in days

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 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 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 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

Digester Types

Plug Flow Digester

- 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.
- Digester retention time shall be $\geq$ 20 days.
- Operational temperature shall be mesophilic (35 ºC to 40 ºC).
- The length to width ratio of digester flow path shall be between 3.5:1 and 5:1.
- The ratio of flow path width to fluid depth shall be less than 2.5:1.
- The shape of the floor and walls shall be uniform to minimize mixing.

Complete Mix Digester

- Total solids concentration of manure influent shall be from 2.5 to 10percent.
- Digester retention time shall be $\geq$ 17 days.
- Operational temperature shall be mesophilic (35 ºC to 40 ºC).
- Appropriate mixing devices shall be provided to assure a complete mix process.

Fixed Film Digester

- 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.
- Digester retention time shall range from 1 to 6 days, depending on waste biodegradability.
- Operational temperature shall range from 15 ºC (59 ºF) to 40 ºC (103 ºF).
- Microbial support material with $\geq$ 3 inch openings

Alternative Digester Design Criteria

Design of digesters not meeting the listed design and operational criteria or for a type other than 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 as 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.

   Covers 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 35 ºC and 40 ºC (95 ºF-103 ºF) with an optimum of 37.5 ºC (100 ºF) and daily fluctuation of digester temperature limited to less than 0.55 ºC (1 ºF).

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 - Pipe and/or appurtenances shall meet the following:

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

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.
- Gas pipe installed within buildings shall be of type approved for combustible gas.
- 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:

- "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 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 m (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.

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:

1. Layout and location of livestock facilities, waste collection points, waste transfer pipe, digester, biogas utilization facilities, and digester effluent storage.
2. Grading plan showing excavation, fill, and drainage, as appropriate.
3. Materials and structural details of the digester, including all premixing tanks, inlets, outlets, pipes, pumps, valves, and appurtenances as appropriate to the complete system.
4. 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.
5. 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.

Appendix F National Resource Conservation Service Practice Standards

WASTE FACILITY COVER

(No.)

CODE 367

DEFINITION

A fabricated rigid, semi-rigid, or flexible membrane over a waste treatment or storage facility.

PURPOSE

To cover a waste facility for:

- water quality improvement
- air quality improvement
- capture of biogas for energy production

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Exclusion of precipitation from an animal waste storage or treatment facility will improve management of an existing or planned system.
- Capture and controlled release or flaring of emissions from an existing or planned agricultural waste storage will improve air quality.
- Bio-treatment of emissions from an existing or planned waste storage or treatment facility will improve air quality
- Biogas production and capture for energy are components of an existing or planned animal waste system.

CRITERIA

General Criteria Applicable to All Purposes

Laws and Regulations. Cover systems for animal waste facilities must be planned, designed, and constructed to meet all federal, state and local regulations.

Service Life. The cover and appurtenances shall be designed to provide a service life of not less than 10 years.

Materials. The type, thickness and material properties of the cover and any supporting members shall account for all loads and stresses due to operational, environmental, and climatic conditions.

Flexible membrane materials, used for fabrication of inflated and floating covers, shall be certified by the manufacturer as suitable for the intended application.

Loads. Where applicable, the membrane cover and support system shall be designed to resist snow and wind loads as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads.

Biogas Emissions. The cover system shall provide for capture and control of biogas, bio-reduction and direct release of gaseous emissions, or contain and release of gaseous emissions, as appropriate.

Capture and Control

The cover system shall be designed to capture biogas emissions and transfer to point of discharge without mixing with air. The point of discharge shall be equipped with a flare or utilization equipment as appropriate.

Bio-reduction and Direct Release

The cover shall be fabricated of a permeable composite membrane designed to promote biological treatment of gaseous emissions. Gaseous emissions pass through the membrane for direct release to the atmosphere.

Contain and Release

The cover system is designed for rainfall exclusion and not to specifically capture biogas. Therefore special handling or treatment of biogas emissions is not required except as necessary to prevent undue safety hazards.

Anchorage. The cover anchorage system shall be designed in a manner to resist internal gas pressures, corrosive environment, wind loads or other forces as appropriate to the cover system.

Repair. New and aged flexible cover materials shall be readily repairable by solvent, adhesive, or

thermoplastic welding. Semi-rigid cover material shall be repairable by sectional replacement.
Precipitation. Impermeable covers shall direct precipitation to collection points for removal by pumping or by controlled release to suitable grassed or otherwise stabilized areas for discharge.

Access. Covers shall be removable or otherwise provided with suitable equipment access as necessary for normal operation and maintenance of the waste facility.

Safety. The cover shall include safety features, including fences and warning signs as appropriate to prevent undue hazards.

As a minimum all covers shall include the following:

- "Warning Flammable Gas" and "No Smoking" signs shall be posted.

Where biogas is captured, the gas collection and control system shall be designed in accordance with standard engineering practice for safely handling a flammable gas.

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 flare and the waste facility.

The location of underground gas lines shall be marked with signs to prevent accidental disturbance or rupture.

Additional Criteria for Rigid Covers

Rigid covers shall meet the structural requirements of Practice Standard 313, Waste Storage Facility.

The cover or cover vessel design shall include provisions for fail safe pressure relief. Maximum pressure shall not exceed 12 inches water column.

Additional Criteria for Inflated Covers

Covers inflated and supported by forced air from mechanical means shall be:

- Equipped with a warning system to notify operator of blower failure.
- Provided with a support system to limit cover collapse in the event the blower fails and for access of equipment.
- Provided with a suitable access port for normal maintenance equipment.

Additional Criteria for Floating Covers

Floating membrane covers shall be supplemented with floatation materials as necessary for proper function, operation, and maintenance.

Minimum membrane or composite membrane thickness shall be 40 mils.

Additional Criteria for Energy Production

The cover materials and all appurtenances such as weights and floats shall be designed to capture and convey biogas to the gas collection system. The cover design shall provide for the following:

1. Air Infiltration. The cover system and appurtenances, including perimeter soil slopes above the water line for in-ground digesters, shall be designed to exclude the entrance of air under all operating conditions.
2. Material. The minimum material thickness for flexible geomembrane covers shall be:
   - 40 mils for non reinforced material
   - 36 mils for reinforced materials
3. Gas Collection, Control, and Utilization. The collection of biogas and flaring or other end use shall meet appropriate criteria in Practice Standard 365, Anaerobic Digester – Ambient Temperature.

CONSIDERATIONS

Animal waste storage facilities can release large amounts of biogas at certain times of the year. The cover and gas collection system should be designed for release of this gas.

Storage of biogas should be considered when installing flexible covers over storage impoundments (lagoons) to attenuate gas supply for end use or controlled release.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and

shall describe the requirements for applying the practice to achieve its intended use.

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 used for its design.

When gas storage is included in the system design, the plan shall contain instructions as to limits of cover ballooning and emergency procedures if control equipment fails.

Warranties. The cover manufacturer and or installer shall warrant the cover for the intended use and design life, provide maintenance instructions, and certify that the cover is properly installed.

WASTE STORAGE FACILITY

(No.)

CODE 313

DEFINITION

A waste storage impoundment made by constructing an embankment and/or excavating a pit or dugout, or by fabricating a structure.

PURPOSE

To temporarily store wastes such as manure, wastewater, and contaminated runoff as a storage function component of an agricultural waste management system.

CONDITIONS WHERE PRACTICE APPLIES

- Where the storage facility is a component of a planned agricultural waste management system
- Where temporary storage is needed for organic wastes generated by agricultural production or processing
- Where the storage facility can be constructed, operated and maintained without polluting air or water resources
- Where site conditions are suitable for construction of the facility
- To facilities utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.
- To fabricated structures including tanks, stacking facilities, and pond appurtenances.

CRITERIA

General Criteria Applicable to All Waste Storage Facilities.

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

Location. To minimize the potential for contamination of streams, waste storage facilities should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year flood event, or larger if required by laws, rules, and regulations. Waste storage facilities shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values.

Storage Period. The storage period is the maximum length of time anticipated between emptying events. The minimum storage period shall be based on the timing required for environmentally safe waste utilization considering the climate, crops, soil, equipment, and local, state, and federal regulations.

Design Storage Volume. The design storage volume equal to the required storage volume, shall consist of the total of the following as appropriate:

(a) Manure, wastewater, and other wastes accumulated during the storage period

(b) Normal precipitation less evaporation on the surface area (at the design storage volume level) of the facility during the storage period

(c) Normal runoff from the facility's drainage area during the storage period

(d) 25-year, 24-hour precipitation on the surface (at the required design storage volume level) of the facility

(e) 25-year, 24-hour runoff from the facility's drainage area

(f) Residual solids after liquids have been removed. A minimum of 6 inches shall be provided for tanks

(g) Additional storage as may be required to meet management goals or regulatory requirements

Inlet. Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage and ultraviolet ray deterioration while incorporating erosion protection as necessary.

Emptying Component. Some type of component shall be provided for emptying storage facilities. It may be a facility such as a gate, pipe, dock, wet well, pumping platform, retaining wall, or ramp. Features to protect against erosion, tampering, and accidental release shall be incorporated as necessary.

Accumulated Solids Removal. Provision shall be made for periodic removal of accumulated solids to preserve storage capacity. The anticipated method for doing this must be considered in planning, particularly in determining the configuration of ponds and type of seal, if any.

Safety. Design shall include appropriate safety features to minimize the hazards of the facility. Ramps used to empty liquids shall have a slope of 4 horizontal to 1 vertical or flatter. Those used to empty slurry, semi-solid, or solid waste shall have a slope of 10 horizontal to 1 vertical or flatter unless special traction surfaces are provided. Warning signs, fences, ladders, ropes, bars, rails, and other devices shall be provided, as appropriate, to ensure the safety of humans and livestock. Ventilation and warning signs must be provided for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation. Pipelines shall be provided with a water-sealed trap and vent, or similar device, if there is a potential, based on design configuration, for gases to enter buildings or other confined spaces. Ponds and uncovered fabricated structures for liquid or slurry waste with walls less than 5 feet above ground surface shall be fenced and warning signs posted to prevent children and others from using them for other than their intended purpose.

Erosion Protection. Embankments and disturbed areas surrounding the facility shall be treated to control erosion.

Liners. Liners shall meet or exceed the criteria in Pond Sealing or Lining (521).

Additional Criteria for Waste Storage Ponds

Soil and foundation. The pond shall be located in soils with an acceptable permeability that meets all applicable regulation, or the pond shall be lined. Information and guidance on controlling seepage from waste impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The pond shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless features of special design are incorporated that address buoyant forces, pond seepage rate and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains, if feasible, to meet this requirement.

Maximum Operating Level. The maximum operating level for waste storage ponds shall be the pond level that provides for the required volume less the volume contribution of precipitation and runoff from the 25-year, 24-hour storm event plus the volume allowance for residual solids after liquids have been removed. A permanent marker or recorder shall be installed at this maximum operating level to indicate when drawdown should begin. The marker or recorder shall be referenced and explained in the O&M plan.

Outlet. No outlet shall automatically release storage from the required design volume. Manually operated outlets shall be of permanent type designed to resist corrosion and plugging.

Embankments. The minimum elevation of the top of the settled embankment shall be 1 foot above the waste storage pond's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall be not less than 5 percent. The minimum top widths are shown in Table F-1. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1

vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

Table F-1 – Minimum Top Widths

Total embankment Height, ft.	Top Width, ft.
15 or less	8
15 – 20	10
20 – 25	12
25 – 30	14
30 – 35	15

Excavations. Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

Additional Criteria for Fabricated Structures

Foundation. The foundations of fabricated waste storage structures shall be proportioned to safely support all superimposed loads without excessive movement or settlement.

Where a non-uniform foundation cannot be avoided or applied loads may create highly variable foundation loads, settlement should be calculated from site-specific soil test data. Index tests of site soil may allow correlation with similar soils for which test data is available. If no test data is available, presumptive bearing strength values for assessing actual bearing pressures may be obtained from Table F-2 or another nationally recognized building code. In using presumptive bearing values, adequate detailing and articulation shall be provided to avoid distressing movements in the structure.

Foundations consisting of bedrock with joints, fractures, or solution channels shall be treated or a separation distance provided consisting of a minimum of 1 foot of impermeable soil between the floor slab and the bedrock or an alternative that will achieve equal protection.

Table F-2 - Presumptive Allowable Bearing Stress Values[1]

Foundation Description	Allowable Stress
Crystalline Bedrock	12000 psf
Sedimentary Rock	6000 psf
Sandy Gravel or Gravel	5000 psf
Sand, Silty Sand, Clayey Sand, Silty Gravel, Clayey Gravel	3000 psf
Clay, Sandy Clay, Silty Clay, Clayey Silt	2000 psf

[1] Basic Building Code, 12th Edition, 1993, Building Officials and Code Administrators, Inc. (BOCA)

Liquid Tightness. Applications such as tanks, that require liquid tightness shall be designed and constructed in accordance with standard engineering and industry practice appropriate for the construction materials used to achieve this objective.

Structural Loadings. Waste storage structures shall be designed to withstand all anticipated loads including internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, water pressure due to seasonal high water table, and frost or ice pressure and load combinations in compliance with this standard and applicable local building codes.

The lateral earth pressures should be calculated from soil strength values determined from the results of appropriate soil tests. Lateral earth pressures can be calculated using the procedures in TR-74. If soil strength tests are not available, the presumptive lateral earth pressure values indicated in Table F-3 shall be used.

Appendix F National Resource Conservation Service Practice Standards

TABLE F-3 - LATERAL EARTH PRESSURE VALUES[1]

Soil		Equivalent fluid pressure (lb/ft^2/ft of depth)			
		Above seasonal high water table[2]		Below seasonal high water table[3]	
Description[4]	Unified Classification[4]	Free-standing walls	Frame tanks	Free-standing walls	Frame tanks
Clean gravel, sand or sand-gravel mixtures (maximum 5% fines)[5]	GP, GW, SP, SW	30	50	80	90
Gravel, sand, silt and clay mixtures (less than 50% fines) Coarse sands with silt and and/or clay (less than 50% fines)	All gravel sand dual symbol classifications and GM, GC, SC, SM, SC-SM	35	60	80	100
Low-plasticity silts and clays with some sand and/or gravel (50% or more fines) Fine sands with silt and/or clay (less than 50% fines)	CL, ML, CL-ML SC, SM, SC-SM	45	75	90	105
Low to medium plasticity silts and clays with little sand and/or gravel (50% or more fines)	CL, ML, CL-ML	65	85	95	110
High plasticity silts and clays (liquid limit more than 50)[6]	CH, MH	-	-	-	-

[1] For lightly-compacted soils (85% to 90% maximum standard density.) Includes compaction by use of typical farm equipment.
[2] Also below seasonal high water table if adequate drainage is provided.
[3] Includes hydrostatic pressure.
[4] All definitions and procedures in accordance with ASTM D 2488 and D 653.
[5] Generally, only washed materials are in this category
[6] Not recommended. Requires special design if used.

Lateral earth pressures based upon equivalent fluid assumptions shall be assigned according to the following conditions:

- **Rigid frame or restrained wall.** Use the values shown in Table F-3 under the column "Frame tanks," which gives pressures comparable to the at-rest condition.
- **Flexible or yielding wall.** Use the values shown in Table F-3 under the column "Free-standing walls," which gives pressures comparable to the active condition. Walls

in this category are designed on the basis of gravity for stability or are designed as a cantilever having a base wall thickness to height of backfill ratio not more than 0.085.

Internal lateral pressure used for design shall be 65 lb/ft^2 where the stored waste is not protected from precipitation. A value of 60 lb/ft^2 may be used where the stored waste is protected from precipitation and will not become saturated. Lesser values may be used if supported by measurement of actual pressures of the waste to be stored. If heavy equipment will be operated near the wall, an additional two feet of soil surcharge shall be considered in the wall analysis.

Tank covers shall be designed to withstand both dead and live loads. The live load values for covers contained in ASAE EP378.3, Floor and Suspended Loads on Agricultural Structures Due to Use, and in ASAE EP 393.2, Manure Storages, shall be the minimum used. The actual axle load for tank wagons having more than a 2,000 gallon capacity shall be used.

If the facility is to have a roof, snow and wind loads shall be as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads. If the facility is to serve as part of a foundation or support for a building, the total load shall be considered in the structural design.

Structural Design. The structural design shall consider all items that will influence the performance of the structure, including loading assumptions, material properties and construction quality. Design assumptions and construction requirements shall be indicated on standard plans.

Tanks may be designed with or without covers. Covers, beams, or braces that are integral to structural performance must be indicated on the construction drawings. The openings in covered tanks shall be designed to accommodate equipment for loading, agitating, and emptying. These openings shall be equipped with grills or secure covers for safety, and for odor and vector control.

All structures shall be underlain by free draining material or shall have a footing located below the anticipated frost depth. Fabricated structures shall be designed according to the criteria in the following references as appropriate:

- Steel: "Manual of Steel Construction", American Institute of Steel Construction.
- Timber: "National Design Specifications for Wood Construction", American Forest and Paper Association.
- Concrete: "Building Code Requirements for Reinforced Concrete, ACI 318", American Concrete Institute.
- Masonry: "Building Code Requirements for Masonry Structures, ACI 530", American Concrete Institute.

Slabs on Grade. Slab design shall consider the required performance and the critical applied loads along with both the subgrade material and material resistance of the concrete slab. Where applied point loads are minimal and liquid-tightness is not required, such as barnyard and feedlot slabs subject only to precipitation, and the subgrade is uniform and dense, the minimum slab thickness shall be 4 inches with a maximum joint spacing of 10 feet. Joint spacing can be increased if steel reinforcing is added based on subgrade drag theory.

For applications where liquid-tightness is required such as floor slabs of storage tanks, the minimum thickness for uniform foundations shall be 5 inches and shall contain distributed reinforcing steel. The required area of such reinforcing steel shall be based on subgrade drag theory as discussed in industry guidelines such as American Concrete Institute, ACI 360, "Design of Slabs-on-Grade".

When heavy equipment loads are to be resisted and/or where a non-uniform foundation cannot be

avoided, an appropriate design procedure incorporating a subgrade resistance parameter(s) such as ACI 360 shall be used.

CONSIDERATIONS

Waste storage facilities should be located as close to the source of waste and polluted runoff as practicable.

Non-polluted runoff should be excluded from the structure to the fullest extent possible except where its storage is advantageous to the operation of the agricultural waste management system.

Freeboard for waste storage tanks should be considered.

Solid/liquid separation of runoff or wastewater entering pond facilities should be considered to minimize the frequency of accumulated solids removal and to facilitate pumping and application of the stored waste.

Due consideration should be given to environmental concerns, economics, the overall waste management system plan, and safety and health factors.

Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Required Volume.

Features, safeguards, and/or management measures to minimize the risk of failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 4 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 4 may be significantly affected:

1. An auxiliary (emergency) spillway
2. Additional freeboard
3. Storage for wet year rather than normal year precipitation
4. Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes
5. Secondary containment

Table F-4 - Potential Impact Categories from Breach of Embankment or Accidental Release

1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries
2. Critical habitat for threatened and endangered species.
3. Riparian areas
4. Farmstead, or other areas of habitation
5. Off-farm property
6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.

The following options should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table F-4 may be significantly affected:

1. Outlet gate locks or locked gate housing
2. Secondary containment
3. Alarm system
4. Another means of emptying the required volume

Considerations for Minimizing the Potential of Waste Storage Pond Liner Failure.

Sites with categories listed in Table F-5 should be avoided unless no reasonable alternative exists. Under those circumstances, consideration should be given to providing an additional measure of safety from pond seepage when any of the potential impact categories listed in Table 5 may be significantly affected.

Table F-5 - Potential Impact Categories for Liner Failure

1. Any underlying aquifer is at a shallow depth and not confined
2. The vadose zone is rock
3. The aquifer is a domestic water supply or ecologically vital water supply
4. The site is located in an area of solutionized bedrock such as limestone or gypsum.

Should any of the potential impact categories listed in Table F-5 be affected, consideration should be given to the following:

1. A clay liner designed in accordance with procedures of AWMFH Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than 1×10^{-6} cm/sec
2. A flexible membrane liner over a clay liner
3. A geosynthetic clay liner (GCL) flexible membrane liner
4. A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness

Considerations for Improving Air Quality

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, and odor, other practices such as Anaerobic Digester – Ambient Temperature (365), Anaerobic Digester – Controlled Temperature (366), Waste Facility Cover (367), and Composting Facility (317) can be added to the waste management system.

Adjusting pH below 7 may reduce ammonia emissions from the waste storage facility but may increase odor when waste is surface applied (see Waste Utilization, 633).

Some fabric and organic covers have been shown to be effective in reducing odors.

PLANS AND SPECIFICATIONS

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

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 the operational requirements for emptying the storage facility. This shall include the requirement that waste shall be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan.

In addition, for ponds, the plan shall include an explanation of the permanent marker or recorder installed to indicate the maximum operating level.

The plan shall include a strategy for removal and disposition of waste with the least environmental damage during the normal storage period to the extent necessary to insure the pond's safe operation. This strategy is for the removal of the contribution of unusual storm events that may cause the pond to fill to capacity prematurely with subsequent design inflow and usual precipitation prior to the end of the normal storage period.

Development of an emergency action plan should be considered for waste storage facilities where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.