

**NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD**

PLUG FLOW DIGESTER

(INTERIM)
CODE 363I

DEFINITION

A constant volume, flow through, controlled temperature tank designed for methane production and recovery in conjunction with a separate waste storage facility at a livestock production operation with manure of suitable consistency for this process.

PURPOSE

To produce and recover methane as an energy source while minimizing odors.

Conditions Where Practice Applies

1. where ruminant manure is scrape collected from concrete surfaces weekly or more often.
2. where methane production and recovery are components of a planned livestock waste management system.
3. where existing waste impoundment(s) can be modified to the requirements of this standard or for new construction.
4. where the influent manure can be collected and delivered to the plug flow digester with a total solids (TS) concentration between 11% and 14%.

CRITERIA

Manure Characteristics. This practice is applicable only to ruminant manures that are collected by solid scraping equipment. Manure should be fresh, less than 7 days old, with minimal amounts of soil, sand, stones or

organic bedding material. Clumps of long straw should be excluded and managed separately.

Total Solids Concentration. Manure influent to the plug flow digester shall contain 11-14% total solids. Water or wastewater, other than needed for dilution to achieve design total solids concentration, shall be excluded.

Rainfall Runoff. Runoff water, clean or contaminated, shall not be allowed to enter the digester.

Safety. If the plug flow 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.

Regulatory. Local, state and federal laws shall be complied with; there may be regulations that affect animal population, distance separations, storage volumes, storage periods, land requirements for nutrient application, fencing, or visual screening in excess of recommendations contained herein.

DIGESTER CRITERIA

Tank Characteristics. The plug flow digester tank shall be corrosion protected metal or reinforced concrete, above or below ground, with allowances for manure entry and exit, heat pipe entry and exit, and special consideration for solid concrete covers or attachment of secured, inflatable covers. Structural digester components shall meet the criteria of Practice Standard 313, Waste Storage Facility, and the following:

1. Design Operating Volume. A plug flow digester shall be sized to retain 18 - 20

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days of manure production and water as needed for dilution.

2. Configuration. The plug flow digester may be either a straight, flow through rectangular tank or, a rectangular or circular tank divided in half that forces flow down the tank, around the end of the center wall and back to an outlet. The ratio of the length to the width of a rectangular plug flow digester shall be between 3.5:1 and 5:1.
3. Operating Depth. The operating depth of a plug flow digester shall be 8 feet or greater.
4. Width to Depth. The ratio of the width to a depth of a plug flow digester shall be less than 2.5:1.
5. Floor. The plug flow digester floor shall be flat.
6. Temperature Control. The tank shall be equipped with a heat exchanger designed to maintain the digester at the operating temperature. The heat exchanger within the digester shall be black iron, steel, copper, or aluminum (Galvanized iron will not per permitted) located below the normal operating fluid level. Tanks shall be equipped with temperature sensors for monitoring internal temperature. The tank surface, walls, and floor shall be insulated as required by local climatic conditions to reduce heat loss and maintain the design operating temperature. Each completed design shall include a summary of the heat balance computations for the heat exchanger and the digester tank at design operating conditions for the mean low winter and mean high summer temperatures.
7. Inlet. Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage, and prevent gas loss. The inlet shall enter the plug flow digester below the permanent liquid level.

8. Outlet. The plug flow 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 facility or waste storage facility.
9. Embankments and disturbed areas surrounding the facility shall be treated to control erosion.

Operating Temperature. The digester shall be maintained between 35 o and 40 o C (95 o -103 o F) with an optimum of 37.5 o C (100 o F) and daily fluctuation of digester temperature limited to less than 0.5 o C (1 o F). Special circumstances may allow higher operating temperatures.

Operating Level. The minimum distance provided between the maximum operating level and the top of the digester wall for plug flow digesters shall be as follows:

floating or inflatable tops.....6 inches
 solid top.....18 inches

Cover. The cover shall be designed to capture and convey the methane to a designed gas outlet. The cover shall also collect and direct precipitation to a designed outlet while exposed to site climatic conditions for its design life. Capital cost, repair technique, and warranty life should be considered when selecting a cover.

Gas Outlet. A digester gas outlet shall be installed to safely convey biogas to its intended use or to a flare where it can be safely burned.

Weather Protection. In areas of extreme wind or excessive snow, appropriate structures may be necessary to protect a secured inflatable digester cover from damage.

Waste Storage Facility. The waste storage facility 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.

CONSIDERATIONS

Location. The plug flow 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 floodplains, and visibility. The plug flow digester should be located near a suitable site for energy utilization equipment. Short distances for the transmission of methane through buried pipe are preferable. Location of the waste storage facility should consider elevation and distance from the plug flow digester to take advantage of gravity flow.

Collection/Mix Tank. A collection/mix tank may be required to accumulate manure, settle foreign material and pretreat influent waste to the appropriate total solids concentration. A volume equal to two days of manure collection is recommended.

Location of Inlet and Outlet. The inlet and outlet devices shall be located as far apart as practical to minimize "short circuiting".

Gas Collection Cover. Gas collection cover can be a floating cover, secured inflatable fabric cover or a solid cover.

Cover Design. A variety of digester cover designs can be considered to meet the needs of the farm. A secured, inflatable cover allows for 4 - 12 hours of biogas storage. A solid cover does not allow for biogas storage.

Insulation. A design heat loss calculation should be completed and certified by a competent designer. Four feet of earthen backfill to within 1 foot of the top of the digester will usually provide adequate insulation. In cold climates, the surface of the digester and a portion of the side walls may require additional insulation. Above ground digesters will require insulation.

Gas Utilization. The most beneficial use of the biogas energy must be investigated and selected. A plug flow digester may require up to 40% of the biogas heat value to maintain the

design temperature in the winter in cold climates. Heat can be recovered in cooling water from internal combustion engines or must be produced for the digester.

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. Vegetative screens or other methods should be used to shield the plug flow digester from public view and improve appearance.

PLANS SPECIFICATIONS

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

Heating System. The plug flow digester heating system should be designed by a competent designer familiar with these systems. The completed drawings shall include a summary of the design parameters and performance limits for the heating system.

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

Gas Use. Plug flow gas use system should be designed by a competent designer familiar with this equipment. Supplier shall warrant the gas use equipment for the 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 operation and maintenance requirements including but not limited to:

1. Proper loading rate of the plug flow digester.

2. Proper operating level of the plug flow digester.
3. Digester temperature control.
4. Estimates of methane production and recovery.
5. Identification of a plan for safe use or flaring of biogas.
6. Environmental considerations for handling/utilization of effluent.
7. Cover and other component maintenance.