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Technical Note ENG FL-24 - Concrete Vat Solids Separator
Dairy Waste Management System

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Definition

A concrete structure with a concrete access ramp, storage pad, solids filtering structure, cells for manure storage, and discharge outlet box. The structure is designed to filter and store a large percentage of the dairy solids for a specified number of days.

Purpose

Dairy waste solids may pose a significant problem in operating an animal waste management system. Many dairy facilities flush manure from the heavy use areas and barns to waste storage ponds and then distribute the solids and effluent to land via an irrigation system. Solids have the potential to clog components of the manure transfer system especially the waste distribution system. When the solids and liquids are collected together, all available nutrients must be applied in an agronomic balance at the same time and location.

The concrete vat solids separator can address many issues dealing with solids collection and separation. If operated properly, the concrete vat solids separator can capture a large percentage of the manure solids which prevent or minimize clogging of manure transfer components. Capture of the nutrients within the collected solids allows the operator more flexibility in utilizing the manure solids (nutrients) either on-farm or off-farm. It also allows more flexibility in the timing of land application, depending on the days of storage, of the manure solids.

Description

The concrete separator consists of two (2) cells of equal size separated by a common interior wall with a ramp into each cell and an access pad. The interior dividing wall is either constructed lower (approximately 4 inches) than the outside walls or a “V” notch is constructed into the top of the wall for emergency overflow into the adjacent cell. Each cell is fitted with an offset outlet box with a vertical timber skimmer, a picket fence (minimum 8 feet long) to filter the discharge, and a pipe outlet in the bottom of the offset outlet box discharging into a waste storage and/or treatment facility. See Figure 1.

The following standards drawings of the concrete vat type solids separator can be downloaded from the NRCS Florida eFOTG web site.

FL-801A1, Manure Solids Separator - Plan and Section
FL-801A2, Manure Solids Separator - Details Picket Fence Screen,
FL-801A3, Manure Solids Separator Inlet Details

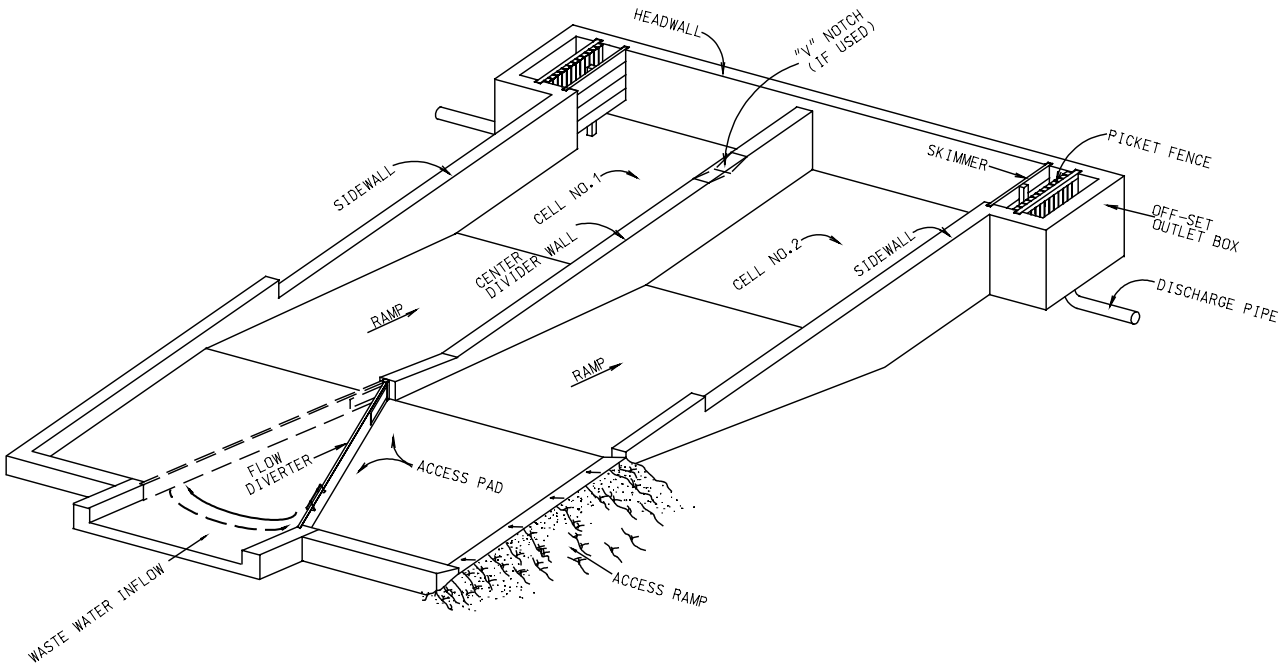

Figure 1 - Concrete Vat Solids Separator

Sizing

Several publications recommend 0.96 cu. ft. of solids per 1000 pound (EAU) dairy cow confined 24 hours per day. The 0.96 cu. ft. of solids per EAU was confirmed to work in Florida based on a case study. The minimum manure storage requirement for a dairy operation will be determined by applying the following formula:

$$EAU = \frac{\text{Avg. weight of animals x Number of Animals}}{1000}$$

Volume (ft^3) = (# EAUs)(% C.T.)(% C.A.)(days of storage)(0.96 ft^3/EAU/day)

% C.A. is percentage of confinement area contributing waste to solids separator.

% C.T. is percentage of confinement time per day in C.A. contributing waste to the separator.

Design Considerations

Ensure that adequate storage is available in each cell to temporarily store the total volume of flush. This will allow the solids separator to slowly discharge. This volume of storage for the inflow should be available in the cell when filled with solids.

Add additional storage as needed when bedding material from free stall barns will enter the system.

To the greatest extent possible, prevent clean storm runoff from entering the concrete solids separator.

Install the outlet pipe from each cell vertically into the bottom of the offset box. This is to maximize out flow with minimal head after the wastewater has discharged through the picket fence.

Construct the bottom of each cell with a slight positive grade to the pipe outlet. Allowing most of the liquid to discharge will enhance drying of the stored solids and easier removal.

Determining nutrient retained in solids separator

Determining the amount of nutrients in the solids from the vat solids separator is important in developing a nutrient management plan. To determine the amount of nutrients retained in the solids separator the following information is required:

- volume of solids retained,
- weight of solids retained,
- bulk density of solids,
- number of days the waste is collected in the solids separator cell,
- number of cows,
- average weight of the cows,
- confinement time per day
- percentage of confinement area (CA) contributing waste to the solids separator,
- nutrient content of the feed, and
- lab results with nutrient content of the solids from the solids separator.

Volume of solids retained is obtained by measuring the dimensions of the solids in the solids separator and calculating the volume. Normally, the dimensions of the solid separator are a known value for each cell.

Example

volume of a full cell is 7,560 ft^3
number of days waste is collected in the solids separator = 14 days
average weight of cows = 1,300 lbs
number of cows = 1,000
confinement time = 10 hours
% CA contributing to the solids separator = 100%
bulk density of the solids in the solids separator is assumed to be 62.4 lbs/ft^3

Knowing the volume and bulk density,

weight of solids = volume of solids retained (ft^3) x bulk density (lbs/ft^3))

weight of solids retained = (7,560 ft^3) x (62.4 lbs/ft^3) = 471,744 lbs

$$\% \text{ waste retained in solids separator} = \frac{\text{confinement time (hrs)} \times \% \text{ CA}}{24 \text{ hours}}$$

$$= \frac{10 \text{ hours x } 100\%}{24 \text{ hours}} = 41.7$$

$$\text{EAU} = \frac{\text{no. of cows x avg. weight of cows (lbs)}}{1{,}000} = \frac{1{,}000 \text{ x } 1{,}300 \text{ lbs}}{1{,}000} = 1{,}300$$

Total nutrient produced that will go through the solids separator

The nutrient content of the waste is based on the feed diet of the cows. For this example, cows are fed a high protein, high P, and high K feed. The waste characteristics from the AWMFH Table FL4-5 are:

Total N (NRC, High)	0.50 lb/day/EAU
Phosphorus (diet 0.6% P)	0.13 lb/day/EAU
Potassium (diet 1.2% K)	0.28 lb/day/EAU

$$\text{Total N} = \frac{\text{EAU x \% waste retained in vat solids separator x number of days x N produced (Table FL4-5)}}{100}$$

$$= \frac{1{,}300 \text{ EAU x } 41.7\text{x } 14 \text{ days x } 0.50 \text{ lb N/day/EAU}}{100} = 3{,}795 \text{ lbs N for every 14 days}$$

$$\text{Total P} = \frac{\text{EAU x \% waste retained in vat solids separator x number of days x P produced (Table FL4-5)}}{100}$$

$$= \frac{1{,}300 \text{ EAU x } 41.7\text{x } 14 \text{ days x } 0.13 \text{ lb P/day/EAU}}{100} = 987 \text{ lbs P for every 14 days}$$

$$\text{Total K} = \frac{\text{EAU x \% waste retained in vat solids separator x number of days x K produced (Table FL4-5)}}{100}$$

$$= \frac{1{,}300 \text{ EAU x } 41.7\text{x } 14 \text{ days x } 0.28 \text{ lb K/day/EAU}}{100} = 2{,}125 \text{ lbs K for every 14 days}$$

Nutrient retained in solids separator.

The following information was obtained from the lab.

Total Nitrogen N	4,375 mg/kg	9 lbs/ton
Total Elemental P -	806 mg/kg	2 lbs/ton
Total Elemental K -	596 mg/kg	1 lb/ton

$$N = \frac{\text{weight of solids retained (lbs) x N content of solids from lab (lbs N/ton)}}{\text{2,000 lbs/ton}}$$

$$N = \frac{471{,}744 \text{ x } 9 \text{ lbs N/ton}}{\text{2,000 lbs/ton}} = 2{,}123 \text{ lbs N}$$

$$P = \frac{\text{weight of solids retained (lbs) x P content of solids from lab (lbs P/ton)}}{\text{2,000 lbs/ton}}$$

$$P = \frac{471{,}744 \text{ x } 2 \text{ lbs P/ton}}{\text{2,000 lbs/ton}} = 472 \text{ lbs P}$$

$$K = \frac{\text{weight of solids retained (lbs) x K content of solids from lab (lbs K/ton)}}{\text{2,000 lbs/ton}}$$

$$K = \frac{471{,}744 \text{ x } 1 \text{ lb K/ton}}{\text{2,000 lbs/ton}} = 236 \text{ lbs K}$$

Percentage of nutrient retained in solids separator.

$$\text{N retained, \%} = \frac{\text{N retained in vat solids separator}}{\text{Total N produced in 14 days}} \text{ x } 100 = \frac{2{,}123 \text{ lbs}}{3{,}795 \text{ lbs}} = 55.9$$

$$\text{P retained, \%} = \frac{\text{P retained in vat solids separator}}{\text{Total P produced in 14 days}} \text{ x } 100 = \frac{472 \text{ lbs}}{987 \text{ lbs}} = 47.8$$

$$\text{K retained, \%} = \frac{\text{K retained in vat solids separator}}{\text{Total K produced in 14 days}} \text{ x } 100 = \frac{236 \text{ lbs}}{2{,}125 \text{ lbs}} = 11.1$$

Operation and Maintenance

The effectiveness of the concrete solids separator to collect solids and nutrients is dependent upon an effective operation and maintenance program. The number of days for collecting solids that work well is 10 - 20 days per cell. The efficiency of a vat solids separator in capturing a greater percentage of the manure solids is unknown for systems with more than 20 days of storage per cell. Additional case studies are needed to determine the effectiveness of capturing solids and retaining nutrients for storage periods greater than 20 days per cell.

The concrete solids separator slows the flow to a very slow velocity allowing most of the fines to settle out of the effluent. As the manure solids are collected in the cell, the existing solids act as a filter for new solids introduced into the cell.

The wastewater entering the solids separator should be diverted to only one cell at a time. This is accomplished by using a flow diverter. The cell in use should continue being used until the waste accumulation has:

1. reached the designed level below the top of the divider wall or below the “v” notch whichever is lower, or
2. the cell has operated for the design days of storage.

Once the waste has reached the design level, sufficient storage should remain that will contain the minimum inflow volume of storage within the cell.

At this time, change cells by swinging the flow diverter into place diverting the flow into the other cell.

The cell that is full of solids should be emptied before the cell collecting inflow is half filled.

A critical element of the solids separator is the timber picket fence, which retains the solids in the cell. It should be checked daily to ensure blockages are not excessive. Some blockage is desirable because it enhances the efficiency of the solid retention. It is important to keep the picket fence in good working order to ensure a large percentage of the manure solids are retained in the cells. Any damage or deteriorated wood or bolts should be promptly replaced.

The wood skimmer at the outlet box should be inspected at the same time as the picket fence. Repair or replace the boards or hardware as needed. Ensure that the opening at the bottom of the skimmer is not blocked.

Inspect the discharge pipe from each cell when inspecting the picket fence. Remove any solids accumulation around the inlet of the pipe and pipe blockage.