FLUSHING MANURE SYSTEMS FOR DAIRY FACILITIES

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Summary

Flushing systems that collect and transport manure are utilized in dairy operations. The sanitation attainable and reduced labor requirements can make flushing a desirable option. Designed flush systems utilize a flush device to release the correct volume of water at the appropriate discharge rate and length of time. This achieves the designed flow velocity, contact time, and depth of water in the gutter to obtain adequate cleaning.

(Key Words: Flushing, Manure, Separator, Lagoon.)

Introduction

Flushing dairy manure is an alternative to blade scraping of freestalls or holding pens. It offers the advantages of labor reduction with automated systems, limited scraping requirements, lower operating cost, drier floors, potential reduction in odor and cleaner facilities. However, an optional method of handling the manure is necessary in colder weather, and scraping may be required. Other disadvantages include the water requirements per cow and the initial fixed cost. A flush system consist of three areas: a high volume flush mechanism, a channel for directional control of the flush water, and the collection of flush water for separation of the liquid and solid. Flushing does not eliminate the need to apply the manure and effluent to land in amounts based on crop utilization.

Design Parameters

Daily water requirements for flushing vary depending on the width, length, and slope of the area to be flushed. Computer simulations show that slope of the building and flush water velocity have the greatest impact on cleaning efficiency. Buildings with alleys sloping 2 to 4% will use significantly less water per day for flushing as compared to alleys at a 1% slope (Tables 1, 2, 3). At an optimal slope of 3%, a minimum flush volume is 100 gal per ft of gutter width for flushing lengths of less than 150 ft. Longer lengths require more water, with a suggested maximum release of 175 gal per ft. A study of six dairies found flush water requirements ranging from 240 to 620 gal per cow per day. Another design procedure suggests selecting the larger of two volumes -either 52 gal per cow per flush or 1.35 gal per sq ft of alley per flush. Normally, recycled water from the lagoon is used for flushing the freestalls, and fresh water is used for flushing the milk parlor and holding pen.

The cleaning efficiency of a flush system depends on the energy of flush water to remove the manure away from the alleys or pens. Most data available are from observation of installed systems rather than optimized design through computer simulations. Present design procedures suggest that the flushing wave needs to be 150 ft in length and 3 in deep and moving at a velocity of 5 fps. Buildings longer than 450 ft require the flush wave to be at least 1/3 of the total length. If the length is less than 150 ft,

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then the design procedures are based on a 10 sec contact time. The amount of time flush water moves past a given selection of the alley is known as contact time. Observation indicates that a contact time of at least 10 sec improves cleaning efficiency. Minimum design values are a flush velocity of 3 fps and a contact time of 5 sec.

System Components

Selection of how flush water is released at the upper end is critical. The two basic methods for flushing use storage structures and pumps. Storage structures have the flush water stored in a tank or tower at the upper end of the area being flushed. A low hp pump is used to transfer water from the lagoon to the storage tank. Flushing tanks have larger discharge openings and a typical depth of 8 to 12 ft. Towers discharge through 12- to 24-in diameter pipe and have depths of 20 ft or more. Types of flush-water storage structures include siphon tanks and gravity flow tanks or towers. These tanks may be either round or square, and towers generally are round. Flushing pumps utilize the lagoon for storing the flush water. A large hp pump then pumps the water to the upper end when flushing is desired.

Tables 1, 2, and 3 provide summaries of volume of water and discharge (release) rate required to meet the recommended design requirements for buildings with different slopes, lengths, and alley widths of 10, 12, and 14 ft, respectively. The time a valve is open is determined by dividing the volume of water required by the release rate. With storage units, the release rate varies from a minimum of 10 sec to more than 60 sec for longer buildings. Release rates can vary from 1,000 gpm to over 15,000 gpm if properly designed. Flush-water pumping systems often are limited by the pump capacity, and the water release rate is 60 sec or longer. Most of the pumping systems are limited to a release rate of less than 2,000 gpm. Higher release volumes require larger hp pumps and transfer pipes. Flush storage structures use less water and depend upon the velocity to move the material the length of the gutter. Flush pumps use higher volumes of water at lower velocities. The material is moved in smaller quantities rather than "en masse" as with the storage structure system.

The channel for controlling the flushing water is normally the freestall alley or holding pen. Flushing dairy facilities is different than flushing swine facilities. Flushing channels in swine buildings range in width from 8 to 12 ft with secondary channel dividers located 3 to 4 ft on center. These secondary channels provide directional control of the flush water as it moves the length of the building. Swine facilities can be flushed year round, because the buildings are warmer. Channels for dairy facilities range from 8 ft to 14 ft in a freestall and up to 40 ft wide in a holding pen. Secondary channel dividers are not used because of vehicle and animal traffic. The flush is dependent on the uniformity of the floor surface. The alley may need scraping in cold weather. Some scraping or manual cleaning along the freestall curb also may be needed, because much of the manure is deposited there. Some try to avoid this cleaning by placing a pipe along the top of the curb to prevent the manure from being deposited against it. Others place a 3/4 to 1 in crown in the alley to direct more flush water along the curbs, if freestalls are along both sides. The crown will interfere with scraping and, generally, the use of level alleys or pens across the width is recommended. A 10 in curb height is suggested to prevent flush water from entering the freestall. Holding pens and milk parlors may require multiple release valves or more frequent flushing to obtain adequate cleaning.

Water is released into the channels using several different methods. The most common method is use of 12-in-diameter "pop-up" or recessed valves, which open manually or automatically. The valves release the water at the center of the alley. The upper 10 to 20 ft of the channel may not clean as well as the remainder of the channel. Automated valves are pneumatically operated and require a source of compressed air. Discharge rate from a valve is influenced by the hydraulic characteristics of the pipeline feeding the valve. Common design procedures use multiple tanks to feed the valve from two sides and increase the discharge rate. Other release methods include a hinged plate, an open pipe, and a gated pipe. The hinged plate is 12 to 18 in wide and located over a flushing trough. Water is released into the trough, and the water pressure raises the hinged plate with the flush water being distributed uniformly across the channel. The hinged plate works well with siphon tanks or other high discharge methods and with wider channels such as the holding pen. An open pipe may be a section of pipe extending out of a tank or an entrance ramp. Normally, these are operated manually using a butterfly value. The flush water is directed toward the alley, and distribution of the full width is poor at the upper end. This type of system may require a steep entrance ramp, which hinders animal and vehicle traffic. The gated pipe developed in Missouri has a diameter of 12 to 14 in and nozzles or gates projecting from it to provide directional control of the flush water being released. The pipe is recessed into the floor so that protrusion is limited to 3 to 4 in above the floor. Vehicle and animal traffic can easily cross the gated pipe design.

The flush water is collected at the lower end of the building in a gutter and directed towards a mechanical separator or gravity settling basin. The flushed material is separated to allow the solids to accumulate in a structure or basin and the liquid to drain to a lagoon. Generally, the freestall buildings are flushed with recycled water from the lagoon, and the holding pens and milking parlor are flushed with fresh water. The mechanical separator may be a screen, press roller, or screw press. A screen allows the liquid to pass through it, but the solids remain on the surface and are transferred to a storage area. With a press roller, the flushed material passes through a pair of rollers and the water drains away. The pressing action is designed to produce a drier material. The third mechanical separator is the screw press, which uses more pressure to separate liquids and solids. Gravity type systems use a settling basin to settle out the solids and drain off the liquids. The solids are generally moved to a drying area prior to transporting to a field. Table 4 shows the weight of manure that has to be hauled to a field at different moisture contents and herd size. We assumed that the cows produce 120 lb of manure per day at an initial moisture content of 87.3%. The solids portion of the manure will have a moisture content of 60 to 80% upon exiting a mechanical separator. The moisture content of material exiting a gravity settling structure can be above 90%, with the moisture reduction on the dry slab being dependent on the weather.

Dairies using sand-bedded freestalls need to have a sand trap located above the mechanical separator. The abrasive action of the sand on the pumps and screens in mechanical separators decreases the equipment life and increases the maintenance costs. These increased costs have resulted in many dairies using gravity settling basins with sand-bedded manure. However, the increased operating cost of the mechanical separator has to be compared to the increased cost of transporting higher volumes of material to the fields. Design parameters for the sand trap have not been determined. Some data suggest that flush water has to be slowed from 5 fps to 1.5 fps to allow the sand to settle out and the effluent and manure to be transferred to the mechanical or gravity separators.

Conclusions

Flushing can be a viable alternative to scraping of dairy manure. Existing facilities can be constructed for the addition of flushing systems at a later date, even if scraping is planned for in the immediate future. This requires placing the buildings at a 2 to 3 percent slope. A 6 to 8 ft difference in elevation between the lower end of the flushed areas and the lagoon freeboard will be necessary for inclusion of separation equipment and transfer collection gutters. Inclusion of flushing systems in existing buildings has to be determined on an individual basis. An adequate water supply for fresh water flushing of the milking parlor and holding pen also must be available.

Table 1. Volume of Flush Water (gal) Required for Gutters 10 ft Wide Based on Gutter Length and Slope

	Gutter Slope (%)				
Gutter Length (ft)	.5	1	2	3	4
150 ft or less	3,900	2,300	1,300	950	1,100
200	5,250	3,000	1,750	1,250	1,250
300	7,850	4,500	2,600	1,900	1,900
400	10,500	6,000	3,500	2,500	2,500
500	13,100	7,500	4,350	3,100	3,100
600	15,700	9,000	5,200	3,750	3,750
800	20,900	12,000	6,900	5,000	5,000
1000	26,100	15,000	8,650	6,300	6,300
Discharge rate (gpm)	23,500	13,500	7,800	5,600	6,500

Table 2. Volume of Flush Water (gal) Required for Gutters 12 ft Wide Based on Gutter Length and Slope

	Gutter Slope (%)				
Gutter Length (ft)	.5	1	2	3	4
150 ft or less	4,700	2,700	1,550	1,150	1,300
200	6,300	3,600	2,100	1,500	1,500
300	9,400	5,400	3,100	2,250	2,250
400	12,550	7,200	4,150	3,000	3,000
500	15,700	9,000	5,200	3,800	3,800
600	18,800	10,800	6,200	4,500	4,500
800	25,100	14,400	8,300	6,000	6,000
1000	31,340	18,000	10,400	7,500	7,500
Discharge rate (gpm)	28,200	16,200	9,300	6,800	7,700

Table 3. Volume of Flush Water (gal) Required for Gutters 14 ft Wide Based on Gutter Length and Slope

	Gutter Slope (%)				
Gutter Length (ft)	.5	1	2	3	4
150 ft or less	5,500	3,150	1,850	1,350	1,500
200	7,300	4,200	2,400	1,800	1,800
300	11,000	6,300	3,650	2,650	2,650
400	14,650	8,400	4,900	3,500	3,500
500	18,300	10,500	6,050	4,400	4,400
600	21,950	12,600	7,300	5,300	5,300
800	29,250	16,800	9,700	7,000	7,000
1000	36,600	21,000	12,100	8,750	8,750
Discharge rate (gpm)	32,900	18,900	10,900	7,900	9,000

Table 4. Tons of Manure Produced per Day Based on Different Herd Sizes and the Moisture Content of the Solids*

	Herd Size				
Moisture Content	100	200	400	800	1600
30	1.1	2.2	4.4	8.7	17.4
40	1.3	2.5	5.1	10.2	20.3
50	1.5	3.0	6.1	12.2	24.4
60	1.9	3.8	7.6	15.2	30.5
70	2.5	5.1	10.2	20.3	40.6
80	3.8	7.6	15.2	30.5	61.0
87.3	6.0	12.0	24.0	48.0	96.0
90	7.6	15.2	30.5	61.0	121.9

*Assume 120 lb of manure per cow per day at 87.3% moisture.