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# TOWER TANK VALVE FLUSHING SYSTEM FOR DAIRY FACILITIES

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## Summary

Flushing characteristics of a tower tank valve flushing system with a 12-inch-diameter manual valve were determined. Data were obtained using the outside cow alleys in a four-row freestall barn. The alleys were 12 ft wide and 420 ft long with a 2% slope. The average flow rate exceeded 8,000 gallons per minute (gpm) when the average head was above 30 ft and the manual valve opened 80 degrees. Opening the valve to 90 degrees increased the flow rate to over 9,700 gpm. The velocity of the flushing wave was 8.5 fpm with a flow depth of 3.5 in. The estimated wave duration or alley contact time was 14.6 sec with a 25-40 sec release time from the flush tank. The flow rate ranged from 5,300 gpm to 7,200 gpm when the average head was between 16 and 28 ft.


(Key Words: Flushing, Manure, Water Usage, Freestall.)

## Introduction

Flushing systems that collect and transport manure are utilized in dairy operations. They offer the advantage of labor reduction with automated systems, limited scraping requirements, lower operating cost, drier floors, potential reduction in odor, and cleaner facilities. One disadvantage is that an optional method of handling the manure may be necessary during colder weather. Other disadvantages include the water requirements per cow and the initial fixed cost.

Designed flush systems utilize a flush device to release the correct volume of water at the appropriate discharge rate and duration of time. This achieves the designed flow velocity, contact time, and depth of water in the gutter to obtain adequate cleaning.

Daily water requirements for flushing vary depending on the width, length, and slope of the flushed area. Buildings with alleys sloping 2 to 4% will use less water for flushing than alleys with a 1% slope. At an optimal slope of 3%, a minimum flush volume is 100 gal/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/ft. One study found 40 to 50 gal/cow/flush were required for effective flushing. A study of six dairies found flush water requirements ranging from 240 to 620 gal/cow/day. Another design procedure recommended selecting the larger of two volumes, either 52 gal/cow/flush or 1.35 gal/sq ft of alley/flush.

Most flushing systems utilize purchased components that include pipe line systems using pop-up valves or plates and underground piping. The objective of our study was to develop a tower tank valve (TTV) flushing system that could be incorporated into an existing or new dairy using sand-bedded freestalls. Desired flushing characteristics included a release rate of 9,000 to 10,000 gpm, water usage of 4,200 gal/flush, 30 sec flushing interval, and the ability to move sand-laden manure.

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## Procedures

A TTV system was installed at a dairy in north-central Kansas. The freestall building was 420 ft long with a 2% slope. The alleys had a 1-inch slope towards the freestall curb from the outside wall. The four-row barn had 84 free-stalls per row. The feed alley was 14 ft wide, and the cow alley was 12 ft wide.

The TTV flush system consisted of open-top flush tanks that were 10.4 ft in diameter and 38.5 ft tall. The flushing system used a 6- to 7-ft section of 16-inch pipe exiting the tank at a right angle. The 16-inch pipe has a 45E slope inside the tank. Another 6- to 7-ft section of 12-inch pipe, which included a 12-inch manual gate valve, then was used to direct the water to the flush alleys. The pipe outlet directed the water along the freestall curb.

Measurements were made using the upper 200 ft of the 12-ft alleys while the cows were in the milking parlor. Except for the first flush, the alleys were free of manure and sand. During the study, the gate valve was opened 80E for the first study and then 90E during the second study.

Tests were conducted at the site on two separate days. Measurements taken during the study used the 12-ft outside alleys, and the data were averaged together based on initial head. The flush water velocity was measured at a distance of 50 ft and 100 ft from a reference point. The reference point was located 90 ft from the outlet of the flush tank. The water front reached uniform flow prior to the reference point. Stop watches were started as the wave front passed the reference point and then stopped as it traveled past the known distance. The flush velocity was determined by averaging the velocities of the wave traveling 50 and 100 ft.

The flush tanks were equipped with pressure gages to measure the water pressure before and after each flush. The difference in pressure was used to determine the drop in water elevation and the volume of water released. The average discharge rate was determined by the water volume release during a given time. The time interval was based on the time the valve was opened. The actual flush time was normally 2 to 3 sec longer to include the time interval required to fully open the valve. The flush valve was closed after the front had traveled 200 ft or approximately 30 sec. The steady-state release volume was not measured. However, based on the Bernoulli equation and using the friction losses of the different components, the estimated steady state rate was 10,500 gpm.

The flow depth was determined at the reference point and at the 50- and 100-ft intervals. The depth was determined by measuring the distance from the top of the curb to the top of the flush water and then subtracting this value from the total curb height. After the flush tanks were filled, the fill valve was closed. Multiple tests were conducted until the tank depth was below 10 ft.

## Results and Discussions

Table 1 summarizes the results when the valve was 80E open. The discharge rate was a function of initial head and varied from 8,700 gpm to 5,000 gpm. The initial head varied from 34 ft to 16 ft. The wave velocity ranged from 7 to 10 fpm, with an overall average of 8.5 fpm. The average water depth was 4 inches.

Table 2 presents the results of the second study with the valve opened 90E. Discharge rates increased a minimum of 500 gpm compared to opening the valve only 80E with a similar initial head. Velocity was reduced from 11.5 fps to 6.7 fps as the head decreased from over 30 ft to less than 10 ft. The depth of wave also was reduced about 50% as the initial head decreased.

The water usage based on a 8,500 gpm discharge rate and a 30 sec flush is equal to 0.84 gal/square ft, a flow rate of 700 gpm/ft width of gutter, and a water usage of 350 gal/ft of gutter. Based on number of freestalls and flushing three times daily, the water usage was 48 gal/stall/flush or 140 gal/day/stall. Based on a 30 sec flush three times daily in the milk parlor, the water usage in the milk parlor was 39 gal/stall/day. Visual inspections indicated that the flush system removed the sand and manure from the alleys.

## Conclusions

Procedures were developed for determining on-site performance of flushing systems. The flushing parameters of a TTV flush system exceeded current design recommendations. The modifications simplified the construction process and maintenance. If repairs are necessary, the whole system does not have to be drained, unless the pump has to be replaced. The manual valves can be replaced by electric-driven actuators with flush intervals based on time. The TTV flush system also is able to adapt to existing dairies, providing they have room to handle the flush water at the lower end. One disadvantage to a TTV flush system is that more tanks are required. The initial cost appears to be similar to that of pipe line systems using underground piping to equalize the pressure between two tanks.

The flush tank release rate be considered at the upper and lower ends of the alleys. Sand traps and gravity solid settling basins need to be designed to handle higher velocities of flush water. Based on visual inspection of the alleys, we suggest a minimum flush velocity of 7.5 fps and preferably 10 fps for sand-bedded freestalls. Current recommendations on release rates appear to be adequate based on this study and with 400 ft alleys. The water depth at the freestall curb should be a minimum of 3 inches, with 4 inches preferred. The energy of the flush water needs to be directed along the freestall curb rather than in the center of the alley with sand-bedded freestalls. This enables the flushing system to remove sand away from the curbs and avoids having to occasionally scrape the sand away from the curbs. Properly designed flush systems can be utilized for effective removal of sand-laden manure in new or existing dairy facilities.

**Table 1. Characteristics of TTV Flushing System with Valve 80 Degrees Open**

| Initial Head | No. of Observations | Velocity | Flow Rate[1] | Flow Depth | Contact Time[2] |
|---|---|---|---|---|---|
| | | - - fps - - | - - gpm - - | - - inches - - | - - sec - - |
| > 30 | 2 | 10.6 | 8,420 | 4.9 | 11.5 |
| 26 - 30 | 2 | 9.8 | 8,150 | 3.9 | 13.9 |
| 21 - 25 | 3 | 8.5 | 6,360 | 4.2 | 12.2 |
| 16 - 20 | 3 | 7.8 | 5,670 | 3.7 | 13.0 |
| 11 - 15 | No measurements taken | | | | |
| 6 - 10 | No measurements taken | | | | |

[1]Average flow rate based on from opening to closing of valve.
[2]Estimated based on released rate, flow depth, and velocity.

**Table 2. Characteristics of TTV Flushing System with Valve 90 Degrees Open**

| Initial Head | No. of Observations | Velocity | Flow Rate[1] | Flow Depth | Contact Time[2] |
|---|---|---|---|---|---|
| | | - - fps - - | - - gpm - - | - - inches - - | - - sec - - |
| > 30 | 3 | 11.5 | 9,740 | 3.6 | 11.2 |
| 26 - 30 | 3 | 10.8 | 8,630 | 3.6 | 11.9 |
| 21 - 25 | 2 | 9.4 | 7,760 | 3.0 | 13.4 |
| 16 - 20 | 3 | 8.3 | 7,390 | 3.3 | 15.4 |
| 11 - 15 | 3 | 7.6 | 5,940 | 3.0 | 16.3 |
| 6 - 10 | 3 | 6.7 | 5,010 | 2.5 | 20.0 |

[1]Average flow rate based on from opening to closing of valve.
[2]Estimated based on released rate, flow depth, and velocity.