

## University of Missouri Extension

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# Basic Requirements for Flushing Dairies

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Flushing has become a favorable way for producers to collect and transport manure on their dairy operations. The superior sanitation attainable and reduced labor requirements make flushing the method of choice in many cases. However, for flushing to work, certain criteria must be fulfilled. These criteria include, but are not necessarily limited to, the following:

- Flush water volume.
- Flush water discharge rate.
- Time (duration) of flush water discharge.
- Water flow velocity and depth in the flush gutter.

A properly designed flush system has a flush device that releases the correct volume of water, at the correct discharge rate, and for the correct length of time, to achieve the desired flow velocity and depth of flow in the flush gutter. This publication outlines methods of determining these basic criteria or parameters.

## Basic dairy flush parameters

Experience has shown that Manning's equation for flow in open channels is adequate for dairy flushing. The form of this equation is:

$$V = (1.49 / n) ((W \times D) / (W + 2 \times D))^{2/3} S^{1/2}$$

**W = width of flush gutter or alley, feet**

**S = slope of flush gutter or alley, feet/feet**

**V = velocity of flush water, feet per second. Experience has shown that a velocity of 5 feet per second usually provides sufficient scouring action for acceptable cleaning.**

**D = flow depth of flush water, feet. Experience has shown that a flow depth of 3 inches (0.25 feet) covers most manure accumulations and results in acceptable cleaning.**

**n = channel roughness, no dimension. Experience has shown that a channel roughness of 0.02 is descriptive of dairy flush gutters under normal manure load conditions**

In addition to the above criteria, experience has shown that flow conditions should be maintained a minimum of 10 seconds for adequate cleaning and to approximate the steady flow conditions assumed by the Manning equation. Also, as flush gutters become longer, there is a tendency for the flush wave to "flatten" out as the water flows down the gutter. This effect can be minimized by providing flush volume sufficient to cover at least one-third of the gutter length at the prescribed flow conditions

The flow requirement of 5 feet per second for a 10-second duration implies a theoretical "wave or hydrograph length" of 50 feet. For gutters longer than 150 feet (50 feet x 3 = 150 feet), the flush volume should be increased so that the wave covers at least one-third of the gutter length. For gutters longer than 150 feet, flush volume is based on one-third of the gutter length. And for gutters 150 feet or shorter, flush volume is based on the 10-second duration criteria (or the criteria for a 150-foot gutter).

A slope of 3 percent is most ideal for flushing because the least flush volume and lowest flush discharge rate are required with this slope. Flatter slopes require higher flush volumes and discharge rates because the water must flow deeper than 3 inches to attain the desired 5 feet per second flow velocity. Conversely, steeper slopes require a higher discharge rate to attain the desired 3-inch flow depth (velocity will be greater than 5 feet per second).

With the above flow criteria in mind, the following equations can be developed that describe the pertinent parameters for dairy flushing.

## Flush volume

### Equation 1

For flush gutter slopes less than or equal to 3 percent:

$$VOL = 1.5 \times GL \times GW \times S^{-0.8}$$

**VOL = flush volume, gallons**

**GL = flush gutter length, feet (\*minimum gutter length = 150 feet)**

**GW = flush gutter width, feet**

**S = flush gutter slope, percent**

### Equation 2

For flush gutter slopes greater than 3 percent:

$$VOL = GL \times GW \times 0.623$$

**VOL = flush volume, gallons**

**GL = flush gutter length, feet (\*minimum gutter length =  $87.15 \times S^{0.491}$  feet)**

**GW = flush gutter width, feet**

**S = flush gutter slope, percent**

## Flush gutter flow rate (water release rate)

The water release device for flushing should be designed or selected, and managed to discharge water to the flush gutter at the correct flow rate. This will ensure that the desired flow depth and velocity is obtained in the flush gutter.

### Equation 3

For flush gutter slopes less than or equal to 3 percent:

$$Q = GW \times 1350 \times S^{-0.8}$$

**Q = flush gutter flow rate, gallons per minute**

**GW = flush gutter width, feet**

**S = flush gutter slope, percent**

### Equation 4

For flush gutter slopes greater than 3 percent:

$$Q = GW \times 324.8 \times S^{0.491}$$

**Q = flush gutter flow rate, gallons per minute**

**GW = flush gutter width, feet**

**S = flush gutter slope, percent**

## Flush discharge time

Water release devices for flushing should discharge water at the proper rate and length of time needed to establish the flow conditions (depth, velocity, duration) described above. If tip or rollover tanks are being used, the tank should be tipped such that emptying takes place over a time period equal to the calculated flush discharge time. Similarly, if a valve is being used, the valve should be open for a time duration equal to the flush discharge time. If a self-emptying release device such as a siphon tank is being used, the tank should be designed to empty in the calculated flush discharge time. Hence, flush discharge time is primarily a management rather than a design parameter.

### Equation 5

For flush gutter slopes less than or equal to 3 percent:

$$T = GL \times 0.067$$

**T = flush discharge time, seconds**

**GL = flush gutter length, feet (\*minimum gutter length = 150 feet)**

**Equation 6**

For flush gutter slopes greater than 3 percent:

$$T = 0.115 \times GL \times S^{-0.491}$$

**T = flush discharge time, seconds**

**GL = flush gutter length, feet (\*minimum gutter length =  $87.15 \times S^{0.491}$ )**

**S = flush gutter slope, percent**

Table 1 shows values for flush volume and discharge rate for a 10 foot wide gutter of varying lengths. These values can be changed in proportion to gutter width for gutters narrower or wider than 10 feet.

**Table 1**

Flush volume and discharge rate for a 10 foot wide gutter and various lengths and slopes

Gutter length (feet)	Gutter slope			
	1 percent	2 percent	3 percent	4 percent
	Flush volume <sup>1</sup> (gallons)			
up to 150	2,250	1,300	950	950
200	3,000	1,700	1,250	1,250
250	3,750	2,150	1,550	1,550
300	4,500	2,600	1,850	1,850
350	5,250	3,000	2,180	2,180
400	6,000	3,450	2,500	2,500
Discharge rate <sup>1</sup> (gallons per minute)	13,500	7,750	5,600	6,400

<sup>1</sup>Values for flush volume and discharge rate can be increased or decreased in proportion to gutter width.

**Example**

Flush volume and discharge rate for a 15-foot wide gutter 250 feet long on a 2 percent slope would be: Flush volume (gallons) = 2150 x 1.5 = 3225 gallons; Discharge rate (gallons per minute = 7,750 x 1.5 = 11,625 gallons per minute).

Water release devices for flushing must be designed to discharge at the proper rates as noted in Table 1. Additionally, the water release devices should discharge for the proper length of time to ensure that the proper total volume is discharged. In the case of a tip, or rollover, tank, the tank should empty in this length of time. Or, in the case of a valve release device, the valve should be full open for this length of time. Discharge time

depends only on gutter length and not gutter width. Table 2 shows values for discharge time for various length flush gutters.

**Table 2**

Water release discharge times for flush gutters of various lengths<sup>1</sup>

Flush gutter length (feet)	Discharge time (seconds)	
	Slopes <= 3 percent	Slopes > 3 percent
up to 150	10	10
200	13	12
250	17	15
300	20	17
350	27	23

<sup>1</sup>The values in this table can be used for any width gutter.

## Example

The following example illustrates the use of the above equations in designing components for a dairy flush system.

A flush alley 250 feet long and 13 feet wide in a dairy freestall barn is to be flushed with a pipeline-valve system. The alley has a 2.5 percent slope. What volume of flush water should be used for this alley, what flow rate should the pipeline-valve system be designed to deliver, and how long should the valve be open to deliver the required flush volume?

Since gutter slope is less than 3 percent, calculate flush volume from Equation 1.

$$\text{VOL} = 1.5 \times 250 \times 13 \times 2.5^{-0.8} = 2342 \text{ gallons}$$

Since gutter slope is less than 3 percent, calculate flush discharge rate from Equation 3.

$$Q = 13 \times 1350 \times 2.5^{-0.8} = 8432 \text{ gallons per minute}$$

Flush discharge time (valve-open time) is calculated from Equation 5, since gutter slope is less than 3 percent.

$$T = 250 \times 0.067 = 17 \text{ seconds}$$

## Related MU Extension publications

- G1830, Tip Tank for Flushing Dairy Free-Stall Alleys  
<http://extension.missouri.edu/publications/DisplayPub.aspx?P=G1830>
- WQ308, Flushing Systems for Dairies  
<http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ308>
- WQ313, Flush Gutters for Dairies  
<http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ313>
- WQ315, Tip Tanks for Dairy Flushing  
<http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ315>
- WQ316, Siphon Tanks for Dairy Flushing  
<http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ316>
- WQ317, Pipeline/Valve Systems for Flushing Dairies  
<http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ317>
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