Assessment of Traffic Patterns in LPCV Facilities
"A Collection of Organized Things"

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Take Home Messages

- Milking activities and manure removal are independent procedures, but they interact in low profile cross ventilated housing systems.
- Increasing the number of lactating cow groups may be necessary to reduce the manure scrape distances and time required to clean an alley.
- There are advantages in moving the flush plume from the end to the middle of the pen, irrespective of the number of lactating cow groups. Greater reduction in travel distance is achieved as pen length increases.
- Allow for a pen(s) at the end of the parlor return lane to hold 50% of the cows in a pen so adequate time is allowed for scraping alleys and bedding freestalls.

INTRODUCTION

Assessment of various dairy activities is helpful in evaluating traffic flow in a dairy after it is constructed. Generally, the assessment is based on visual observation and discussions with key personnel. However, prior to construction, a successful dairy requires planning and integrating various components into a unified system, or a collection of organized things. There are many individual systems that must be organized and coordinated for the dairy to operate successfully and traffic to flow smoothly. Success is simply accomplishing what was proposed, and a successful system recognizes that these functions not only interact, but they are interrelated and interdependent. Successful dairies are simple to assess because they operate as unified system.

PROCEDURE INTERACTION

Two independent but interrelated systems that impact traffic flow in a dairy are the milking activities and manure removal. These activities are interrelated because cows are not usually returned to a pen from the milking parlor or transfer lane until manure has been removed from the front or feed alley. Understanding how these two systems impact one another is critical in planning a low profile cross ventilated dairy.

A model was developed to evaluate the interaction between milking and manure removal from pen alleys. Inputs used in the model were as follows:

1. 3,000 lactating cows producing 150 pounds of manure per cow per day
2. 72-stall rotary parlor operating at 90% efficiency (with 7.5 seconds of stall entry time)
3. Pen length based on 1 to 1 stocking density of the feed line
4. Feed space equal to 24 inches per cow. Frequency of manure scraping in the pens equals the milking frequency
5. Rubber tire used for scraping is 8 feet in diameter

5. Maximum depth of manure limited to 7 inches (the height of the freestall curb)
6. Capacity of the rubber tire used for scraping equals the volume of half the tire's diameter plus 25% extra that flows in front of the tire
7. Forward and backward travel speed of the skid steer is 5 miles per hour (mph)
8. Skid steer pushes manure 60% of the time – remainder of the time is for backing up, moving between lanes, and closing gates
9. Additional manure in front of a tire flows at capacity around the edges of the tire
10. Use of a single operator to clean the pens.

Variable inputs in the model were the pen size, plume location and milking frequency. A ratio of milking to manure handling (M2M) greater than 1 indicates that the time for cleaning a pen is less than the time required for milking. An M2M ratio of 1 or less occurs when the time required for cleaning a pen is equal to or greater than the required milking time. In that case, either additional operators are needed or a reduction in parlor throughput is necessary to provide adequate time for manure removal.

Table 1 shows the results of the model for a 3,000 lactating cow dairy. Traditional design guidelines of 8 pens of cows are compared to an increased number of groups, such as 10 or 12. If the plume is located at one end of the alley, a single operator does not have adequate time to clean the pens when milking 2 times per day, regardless of the number of groups. Cleaning the alleys only twice a day when milking 2 times per day requires the operator to move 50% more manure when the pens are scraped. The M2M ratio equals 0.7 for 8 groups, 0.8 for 10 groups, and 1.0 for 12 groups. When milking 3 times per day, the M2M ratio equals 1.0, 1.3 and 1.5 for 8, 10 and 12 groups, respectively. A second operator or a redesign prior to construction may be necessary if the dairy is designed with 8 groups, has an end location of the plume, and the frequency of milking is based on 3 times per day. In naturally ventilated freestall facilities, adding 10 to 20 additional minutes to the milk time in order to compensate for the extra cow travel time to and from the parlor often provides adequate time to thoroughly clean the pens.

Table 1: Impact of Pen Size, Number of Groups, Milking Frequency and Plume Location on Milking to Manure Ratio

Pen Size	Number of Groups	Milking Frequency	Plume Location	Time Requirements per Pen			Ratio of Milking to Manure Handling
				Milking Time (min)	Manure Scrape Time (min)	Single Alley (min)	
375	8	2X**	End of Pen	52	74	37	0.7
375	8	3X*	End of Pen	53	52	26	1.0
300	10	2X	End of Pen	42	50	25	0.8
300	10	3X	End of Pen	42	32	16	1.3
250	12	2X	End of Pen	35	36	18	1.0
250	12	3X	End of Pen	35	24	12	1.5

375	8	2X	Middle of Pen	52	40	20	1.3
300	10	2X	Middle of Pen	42	28	14	1.5
250	12	2X	Middle of Pen	36	20	10	1.8

*Assumes a rubber tire reaches capacity after 150 ft when alleys are scraped 3 times per day
**Assumes a rubber tire reaches capacity after 100 ft when alleys are scraped 2 times per day

The lower half of Table 1 shows the impact of moving the plume to the middle of the pen for a herd milking 2 times per day. Changing the location of the plume reduces the scraping distance (and equipment travel time) to a maximum distance of half the pen length. When the plume is located at the end of a pen, at least 50% of the manure must be scraped over half of the pen length. Changing the plume location increases the M2M ratio from 0.7 to 1.3 for 8 groups, from 1.0 to 1.5 for 10 groups, and from 1 to 1.8 for 12 groups when milking 2 times per day.

Table 2 shows the impact on travel distance of a skid steer or tractor-mounted scraper blade when the plume is moved to the center of a pen. The travel distance per day per pen is decreased by 40 to 50% when the plume is relocated to the center of a pen. Not only is the milking to manure ratio impacted, but the energy use and cost of equipment on the dairy are also positively affected.

Table 2: Impact of Scraping Frequency, Location of Plume and Pen Length on Skid Steer Travel Distance (miles) Per Day When Scraping Two Alleys

Manure Scrape Frequency	Location of Plume	Pen Length (feet)			
		300	600	750	900
3X*	End of pen	1.0 miles	3.4 miles	5.1 miles	7.2 miles
3X	Middle of pen	0.7 miles	2.0 miles	3.8 miles	4.1 miles
2X**	End of pen	0.9 miles	3.2 miles	5.3 miles	6.8 miles
2X	Middle of pen	0.8 miles	1.8 miles	3.0 miles	4.4 miles

*Assumes with 3X scraping the rubber tire reaches capacity at 150 ft
**Assumes with 2X scraping the rubber tire reaches capacity at 100 ft

Milking Activity Considerations

Though milking and manure removal need to be considered together when designing an LPCV facility, specific considerations should be taken into account in regards to milking activity and its impact on traffic flow. Walking distance, defined as the distance from the gate exiting a pen to the holding pen of the parlor, plays a key role in the time needed for milking. Typically, four and six-row freestall and dry lot dairies are designed to limit one-way walking distance to 2,000 feet

or less per day. This design criterion necessitates that a dairy milking 2 times, 3 times, or 4 times per day has pen exits within 1,000, 700 and 500 feet of the parlor. Often in naturally ventilated freestalls at least two or more pens of cows are located at maximum distances from the parlor. Maximum walking distances are often exceeded if exercise lots are placed between freestall buildings. In low profile cross ventilated freestalls, the distance of the farthest pen exit to the holding pen is usually less than 400 feet with daily one-way walking distances of 1,200 feet or less, regardless of milking frequency. As a result, cows return from the milking parlor to the pen more quickly and have more time to feed and rest. The ability to shorten walking distance during milking and provide more time for cows to rest and feed are positive benefits of low profile cross ventilated dairy facilities. However, rapid manure removal needs to also occur so cows are not left standing in the transfer lane waiting for feed, water or rest.

Manure Removal Considerations

Specific considerations regarding traffic flow are also necessary when contemplating the best manure removal system. Parlor type also influences manure handling procedures. Rotary parlors enable individual cows immediately to return to a pen upon completion of milking rather than exiting as a group from a parallel or herringbone parlor. If a rotary parlor is being used, the first cow milked will return approximately 3 minutes faster than when a parallel or herringbone parlor is used. During the time that cows are away for milking, distribution also occurs within a pen. Observations of a naturally ventilated dairy with a D16 parallel parlor show 40 minutes, on average, is the quickest the first cows departed and returned to 108-stall pens located within 500 feet of a parlor (Figure 1). However, the last cows were away from the pen for an average of 73 minutes. The pen average per shift for travel times and milking was 55 minutes. This provides adequate time for scraping alleys and grooming and bedding freestalls.

In LPCV buildings, some cows may be ready to return to a pen before other cows have exited the same pen if they are the first group of the milking shift. The first cows through the milking parlor may be able to return to the pen in 10 to 15 minutes. Ideally, an alley should be cleaned in 15 minutes or less in an LPCV building. Most low profile cross ventilated dairies opt to scrape rather than flush the front (feed) and back (cow) alleys in a pen. Scraping requires more time for cleaning alleys than flushing.

Another manure removal factor that must be considered is the bedding of freestalls. The front alley is generally cleaned prior to bedding the stalls. On non-bedding days, cows are allowed to return to the front alley with access to the feed line while the back alley is scraped. Access to the pen is not possible on bedding days since the bedding equipment utilizes the front alley for bedding while the back alley is being scraped. The return lane between buildings may be used on naturally ventilated freestalls as a temporary holding pen during the bedding operation. This is not possible in low profile cross ventilated freestalls, though, because the parlor is within 50 feet of the housing area. Separate travel lanes to and from the parlor may help improve cow flow in the pens closest to the parlor.

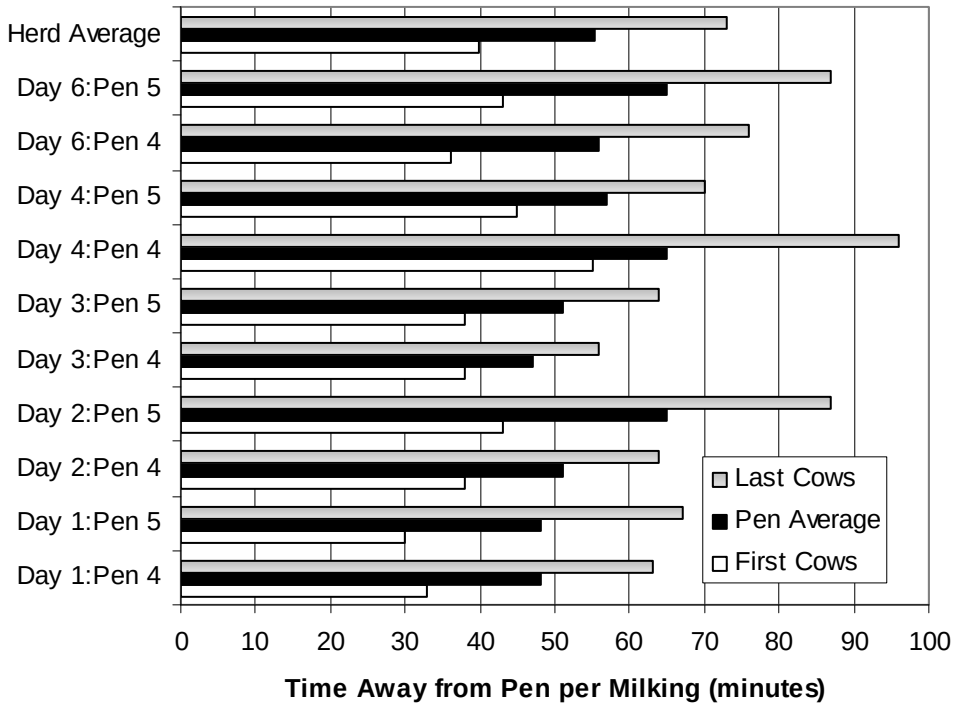

Figure 1: Time Available for Cleaning Alleys, Grooming and Bedding Stalls Based on a Time Motion Study on a Dairy with a D16 Parlor and 500 Feet Walking Distances

Exit / Return Lane Recommendations

The width of exit and return lanes should be increased to prevent having to back up the cows and interrupt milking in LPCV facilities. Current recommendation is to allow enough space in the exit and return lanes to hold 50% of the cows in a group.

Summary

Milking activities and manure removal are two independent but interrelated and crucial systems on a dairy. Understanding how the two systems interact to affect traffic flow is extremely important when designing a dairy. During the design phase, the planners should carefully compare the increased cost of moving a plume to the center of the pen versus utilizing a second operator or experiencing a reduction in parlor performance. Low profile cross ventilated freestall dairies have unique characteristics, as compared to dry lot or traditional 4 or 6-row freestall facilities. Careful planning and attention to interacting details, activities, or functions that may impact dairy traffic flow result in a successful, unified system. The design process allows producers the opportunity to look at all the options and make sound decisions for their operations. There will not be one solution for all dairies.