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Relocation and expansion planning for dairy producers

Abstract
Relocating or expanding a dairy facility requires a tremendous amount of time and planning. Owners or managers of dairies will go through a number of steps including: 1) developing a business plan; 2) choosing a design process; 3) developing specifications; 4) selecting location/site; 5) obtaining permits/legal; 6) obtaining bids; 7) selecting contractors; 8) buying cattle; 9) purchasing feeds; 10) financing; 11) managing construction; 12) hiring and training employees; 13) developing management protocols for the dairy; and 14) managing information flow. The dairy can be divided into these components: 1) milking parlor; 2) cow housing; 3) special needs facility (e.g., hospital, closeups); 4) replacement heifer housing; 5) manure management system; and 6) feed center. This article will focus on milking parlors, cow housing, grouping strategies, and site selection.; Dairy Day, 1999, Kansas State University, Manhattan, KS, 1999;

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RELOCATION AND EXPANSION PLANNING FOR DAIRY PRODUCERS

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Summary

Relocating or expanding a dairy facility requires a tremendous amount of time and planning. Owners or managers of dairies will go through a number of steps including: 1) developing a business plan; 2) choosing a design process; 3) developing specifications; 4) selecting location/site; 5) obtaining permits/legal; 6) obtaining bids; 7) selecting contractors; 8) buying cattle; 9) purchasing feeds; 10) financing; 11) managing construction; 12) hiring and training employees; 13) developing management protocols for the dairy; and 14) managing information flow. The dairy can be divided into these components: 1) milking parlor; 2) cow housing; 3) special needs facility (e.g., hospital, closeups); 4) replacement heifer housing; 5) manure management system; and 6) feed center. This article will focus on milking parlors, cow housing, grouping strategies, and site selection.

(Key Words: Dairy Facilities, Expansion, Cow Comfort.)

Design-Build Concept

Many owners and managers who have made the decision to expand prefer to use the design-build concept or a design team. This concept specifies that a dairy design consultant is employed to work with the dairy management specialist in developing a basic dairy design and program plan to meet the client's needs. The design team consists of a consulting engineer and supporting dairy management specialists, which could include dairy extension faculty, financial advisors, nutritionists, milking equipment manufacturers, and veterinarians. This team approach is an efficient way to integrate desired management into physical facilities.

Options for the Milking Parlor

Evaluating Parlor Performance

Milking parlor performance has been evaluated by time and motion studies to measure steady-state throughput (cows per hour). Steady-state throughput does not include time for cleaning the milking system, maintenance of equipment, effects of group changing, and milking the hospital strings. These studies also allow us to look at the effect of different management variables, including milking interval, detachers, premilking hygiene, number of operators and construction. Examples of different management techniques that affect parlor performance are listed below:

- Data collected in parallel milking parlors indicate that milking cows 3× rather than 2× daily increases throughput 8 to 10%.
- Use of detachers does not increase throughput with the same number of operators.
- Use of predip milking hygiene reduces parlor performance 15 to 20%.

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- Average number of cows milked per operator hour decreases as the number of operators increases from one to four.
- Steady-state throughput is 10 to 12% greater in new parlors than in renovated parlors.

Sizing Parallel and Herringbone Milking Parlors

Table 1 presents the design criteria for parallel and herringbone parlors.

Table 1. Design Criteria for Parallel and Herringbone Parlors

Milking Frequency	Shift Length	Turns per Hour
2×	8.0	4.0
3×	6.5	5.0
4×	5.0	6.0

Typically, milking parlors are sized so that cows can be milked once in 8 hours when milking 2× per day; once in 6.5 hours when milking 3× per day; and once in 5 hours when milking 4x per day. Using these criteria, the milking parlor will be sized to accommodate cleaning and maintenance. The facilities or cow groups are determined based on milking one group in 60 min when milking 2×, one in 40 min when milking 3×, and one in 30 min when milking 4×. Group size is adjusted slightly to be divisible by the number of stalls on one side of the milking parlor. Having as many occupied stalls as possible per cycle maximizes parlor efficiency.

Typically, it is assumed the milking parlor is turned over four and one-half times per hour during milking. The number of cows that will be milked per hour can be calculated using the following formulas:

Total number of stalls × 4.5 = cows milked per hour (CPH)

Number of milking cows = CPH × milking shift length (hours)

Sizing Rotary Parlors

Entry time (seconds/stall), number of empty stalls, number of cows that go around a second time, entry and exit stops, and the size of the parlor (number of stalls) influence the performance of rotary parlors. The entry time will determine the maximum number of cows that can be milked per hour. For example if the entry time is 10 seconds, the maximum throughput will be 360 cows per hour (3600 seconds per hour divided by 10 seconds per stall). This is referred to as theoretical throughput.

Theoretical throughput assumes that the parlor never stops, cows are milked out in one rotation, and a new cow occupies every stall at entry. In reality, there are empty stalls, cows that go around a second time, and times when the rotary table is stopped. Table 2 shows rotary parlor performance at different percentages of theoretical throughput. As the number of empty stalls, cows making a second trip around, and number of stops increase, the percentage of theoretical throughput is decreased.

Table 2. Rotary Parlor Performance

	Theoretical Throughput (cows/hr)				
Time (sec/stall)	100%	90%	80%	70%	60%
8	450	405	360	315	270
9	400	360	320	280	240
10	360	324	288	252	216
11	327	295	262	229	196
12	300	270	240	210	180
13	277	249	222	194	166
14	257	231	206	180	154
15	240	216	192	168	144
16	225	203	180	158	135

Data collected on 14 dairies (Table 3) with recently constructed new rotary parlors showed an average rotation time of 11:45 seconds and throughput averaging 79% of theoretical (100%).

The number of stalls or size of the rotary parlor affects the available unit on-time. Table 4 lists available unit on time for different sizes of rotary parlors at different rotation times. A rotary parlor must be large enough to allow approximately 90% of the cows to be milked out in one trip around the parlor.

A review of the data available today indicates that rotary parlor should be sized at an 11 to 12 sec/stall rotation and 80% of theoretical throughput. The parlor should be large enough to allow 9 min of available unit on-time.

Table 3. Performance of Rotary Milking Parlors on Commercial Dairies

Number of Stalls	Entry per Cow (sec)	Premilking Hygiene	Theory[1] (cows/hr)	Milk Freq.	Actual* (cows/hr)	Number of Operators	Cows Labor/ hr	% Actual/ Theory	Milk[2] Production
32	15:00	wipe-strip	240	2×	195	2	98	81%	57[3]
36	15:00	wipe	240	3×	187	1	187	78%	78
40	11:00	wipe-strip	320	2×	288	2	144	90%	56[4]
40	13:00	wipe-strip	276	2×	245	2	123	89%	56[4]
40	15:00	wipe	240	4×	203	1.5	135	85%	80
40	15:50	full	232	3×	188	4	47	81%	62
40	14:40	wipe-strip	250	3×	205	2	103	82%	65
48	10:00	none	360	2×	263	2	132	74%	60
48	10:00	none	360	2×	279	2	140	78%	59
48	8:80	none	409	2×	251	2	126	61%	60
48	10:25	strip	351	3×	309	3.3	94	88%	66
60	8:00	full	450	3×	336	5	67	75%	65
60	7:80	strip	462	2×	283	5	57	61%	57
72	6:60	strip	545	2×	440	4	110	81%	63
avg.	11:45		338		262		112	79%	64

[1]Steady-state throughput.
[2]Pounds of milk per cow per day.
[3]Jerseys and Guernseys.
[4]Jerseys.

Selecting Parlor Type

Currently, herringbone, parallel, and rotary parlors are the three predominant types of parlors constructed on large dairies. Earlier research indicates that parallel parlors outperformed similarly sized herringbone parlors.

Recently, there has been a renewed interest in rotary parlors. In Table 5, performance of 33 parlors is presented by type, size, and premilking hygiene. Throughput and cows/labor hour are reduced when a full premilking hygiene is used. Additional information is needed in rotary parlors with a full premilking hygiene, because we have evaluated only two.

The square footage required to house the milking parlor is influenced by parlor type. Table 6 shows the estimated square footage of the milk parlor for different sizes of parallel and rotary milking parlors. The square footage requirement for parallels range from 1890 to 5300 sq ft, whereas the area requirement for rotary parlors ranges from 3025 to

9216 sq ft. Producers need to compare the construction cost of the different parlor types they are considering.

If constructing the parlor shell costs $35/sq ft, a double-40 parallel shell would cost $184,400 and an 80-stall rotary shell $322,560. Equipment dealers estimate basic equipment inside the parlor milk line, wash line, basic detacher, and stall at $3,000/stall for herringbone and parallel parlors and $3,400 for a rotary parlor. In parallel and herringbone parlors, the operator pit can be constructed to allow additional stalls to be added as the dairy expands. Expanding rotary parlors is difficult.

In parallel and herringbone parlors, an operator can leave the parlor, and the other operators can continue to milk cows at a slower pace. In a rotary parlor, if one operator needs to leave the parlor, he or she will have to be replaced by another operator. Obviously, choosing what type and size of parlor to build is a very complex decision for a dairy operator.

Table 4. Available Unit On-Time Calculated for Rotary Parlors at Different Rotation Times[1]

		Revolution Time		Available Unit On-Time	
No. of Stalls	Entry Time sec/stall	Seconds/ Revolution	Minutes/ Revolution	Seconds/ Revolution	Minutes/ Revolution
	8	320	5:20	240	4:00
40	10	400	6:40	300	5:00
	12	480	8:00	360	6:00
	15	600	10:00	780	7:30
	8	480	8:00	400	6:40
60	10	600	10:00	500	8:20
	12	720	12:00	600	10:00
	15	900	15:00	750	12:30
	8	576	9:22	496	8:16
72	10	720	12:00	620	10:20
	12	864	14:24	744	12:24
	15	1080	18:00	930	15:30
	8	640	10:40	560	9:20
80	10	800	13:20	700	11:40
	12	960	16:00	840	14:00
	15	1500	20:00	1050	17:30

[1]Assumes 5 stalls for entry and exit, 3 stalls for premilking hygiene, 2 stalls for detaching and postdipping.

Table 5. Performance of Herringbone, Parallel, and Rotary Milking Parlors Using Different Premilking Hygiene on Commercial Dairies

Parlor Type	Total Number of Stalls	Number of Parlors Observed	Premilk. Hygiene[1]	Cows/hr[2]	Number of Operators	Cows Labor/hr
40 Rotary	40	1	Full[4]	188	4.0	47
Double 25 Parallel	50	2	Full[4]	231	4.0	58
60 Rotary	60	1	Full[4]	336	5.0	67
Double 30 Parallel	60	1	Full[4]	272	3.0	91
Double 32 Parallel	64	1	Full[4]	268	3.0	89
Double 35 Parallel	70	1	Full[4]	280	2.5	112
Double 40 Herringbone	80	1	Full[4]	392	7.0	56
Double 40 Parallel	80	1	Full[4]	385	4.0	96
Double 45 Parallel	90	3	Full[4]	396	5.0	79
Double 50 Parallel	100	1	Full[4]	460	5.0	92
32 Rotary	32	1	Min[3]	195	2.0	98
36 Rotary	36	1	Min[3]	187	1.0	187
40 Rotary	40	4	Min[3]	235	1.9	124
48 Rotary	48	3	Attach[1]	264	2.0	132
48 Rotary	48	1	Min[2]	309	3.3	94
Double 28 Herringbone	56	1	Min[2]	252	3.0	84
60 Rotary	60	1	Min[2]	283	5.0	57
Double 30 Parallel	60	2	Min[2]	280	3.0	93
Double 35 Parallel	70	1	Min[2]	352	3.0	117
72 Rotary	72	1	Min[2]	440	4.0	110
Double 40 Herringbone	80	1	Attach[1]	408	4.0	102
Double 40 Parallel	80	1	Min[2]	491	4.0	123
Double 50 Parallel	100	2	Min[2]	609	5.0	122

[1]Attach units. [2]Steady-state throughput. [3]Strip, attach or wipe, strip, and attach. [4]Strip, predip, wipe, attach.

Table 6. Estimated Square Footage Requirements for Rotary and Parallel Milking Parlors

Total Number of Milking Stalls	Milk Parlor Type	Platform Length or Diameter (ft)	Milk Parlor Length (ft)	Milk Parlor Width (ft)	Building Area (ft^2)	Ratio of Square Footage to Milk Stall
40	Double 20 Parallel	45	45	42	1890	47
40	40 Rotary	40	55	55	3025	76
48	Double 24 Parallel	70	70	42	2940	61
48	48 Rotary	48	63	63	3969	83
60	Double 30 Parallel	84	84	42	3528	59
60	60 Rotary	60	75	75	5625	94
80	Double 40 Parallel	106	106	50	5300	66
80	80 Rotary	81	96	96	9216	115

One vs Two Parlors

Some research indicates that two smaller parlors are more efficient than one larger parlor. One study compared two double 20 parallels versus one double 40 parallel. The net parlor return over 15 years was $908,939 greater in the two smaller parlors vs one large parlor. The initial cost of constructing two double 20 parallels was $22,227 higher than constructing one double 40. Constructing two parlors also allows producers to construct the dairy in phases.

Holding Pens

Design of holding pens is based on 15 to 17 sq ft per cow with a minimum capacity of one group of cows. If the wash pen is at a 90° angle to the cow traffic lane or the group size is greater than 200 cows, then the area per cow should be increased to 16 to 17 sq ft. When a wash pen is not used, oversizing the holding pen by 25% allows a second group to be moved into the holding pen, while the crowd gate is pulled forward and milking of the first group is being finished.

Wash Pen Design

The design and management of the wash pen is very important in U.S. dairies. With new regulations on dairy water use and additional EPA manure regulations being put in place each day, wash pen use will come under additional scrutiny.

Wash pen use is essential in open lot dairies. Many new freestall barns are being built without wash pens and will depend on proper freestall management to deliver clean cows to the milking parlor.

The necessary area per cow for proper cow cleaning depends upon several factors:

- If the wash pen is at a 90° angle to the cow traffic lane, additional area is necessary to allow the cows to fit properly into the wash pen.
- As group size increases, the area per cow increases. With group sizes up to 200 cows, a wash pen of 15 sq ft per cow is adequate. With groups above 200 cows, 16 to 17 sq ft per cow will provide adequate space.

Proper design of the sprinkler system is critical for adequate cow cleaning. With solid (concrete or metal) sidewalls, cows will face toward the parlor. This puts the udder next to the wall. A wash line should be placed 18-24 inches from the sidewall and use a pop-up sprinkler design, like a Rain-Jet. Such sprinklers are not as efficient as impact sprinklers like Rain-Birds. However, if all Rain-Birds are used, cows against the wall will not be cleaned well.

After placement of the outside row of Rain-Jets, the remaining sprinklers should be placed on a 5-ft by 6-ft grid. For example, a 40-ft wide holding pen with outside rows 2 feet from the sidewalls would have 5 rows of sprinklers spaced 6 ft apart and 5 ft top to bottom.

A three-stage timer should be used to operate the sprinklers. The timings will affect the amount of water used. This wash system is the largest user of water on the farm. Water use will vary from 18 to 30 gal per cow per wash. The first cycle is the “soak.” Its purpose is to wet the udder and loosen the dirt on the cow. One minute of water application followed by 2 minutes of stand time is adequate. The third cycle is a 3-minute wash period. If cows are still dirty, you should wait 1 minute and wash for 3 minutes again. During the stand time, cows generally move into new positions, resulting in improved wash pen efficiency.

Drip Pen Design

Drip pen area will range from 15 to 17 sq ft per cow. Size the drip pen to hold 100% of the corral or group size, thus allowing adequate time for udders to dry. The minimum size of a drip pen would be two complete turns of the milking parlor. For example, a double-20 herringbone parlor should have a minimum size to hold 80 cows (1200 sq ft). This would allow 24 to 30 min from the time in the wash pen to parlor entry.

Exit Lanes

Exit lane width depends on the number of stalls on one side of the milking parlor. In parlors with 15 stalls or fewer per side, a clear width of 3 ft is acceptable. For parlors containing more than 15 stalls per side, a clear exit lane width of 5 to 6 ft is needed.

Operator Pits

Operator pits are typically 8 ft wide between curbs. In a wedge configuration, operator pits are typically 6 ft wide at the holding pen and 10 ft wide at the breezeway. The cow platform is 38 to 40 inches above the floor of the operator pit. Provisions should be made to allow for floor mat thickness, if mats are to be used. The curb of the cow platform typically overhangs the operator pit wall 9 to 12 inches, depending on the size of the parlor. Normally, the operator pit and cow platform should have a 1% slope to the rear of the milking parlor. Operator pits typically have 2 inches of side slope from the center of the pit to the pit walls.

Constructing the Milking Parlor Shell

Several options are available when constructing the shell of the milking parlor. If no future expansion is planned, the building can be constructed with no room for expansion. This often is done in situations in which acreage is not sufficient for expansion. When long-term plans include expansion, the shell can be constructed with room to add a second parlor or add stalls to an existing parallel or herringbone parlor. If a second parlor is added, usually the two parlors will share a common equipment and milk storage facility. If additional stalls will be added to a parlor, the space should be left in the front of the parlor to reduce cow entry time and allow installation of new stalls without impeding current milking routines.

The final size of the holding pen (number of cows per group) should be sized for the total number of cows that will be milked after the expansion. The milking facility should be ventilated properly to maintain employee and cow comfort. Office, meeting room, break room, and rest room facilities should be incorporated to meet the needs of management.

Selecting Cow Housing

The predominant types of cow housing on large dairies in the U.S. are drylots and freestalls. The choice is based on climate, management style, and equity available for constructing dairy facilities. Typically, drylot facilities can be constructed where the moisture deficit (annual evaporation rate-annual precipitation rate) is greater than 20 inches annually. However, frequency and severity of winter rainfall and blizzards are becoming the key selection criteria. These facilities would provide 500 to 700 sq ft per lactating cow depending on the evaporation rate and 40 sq ft of shade per cow. Windbreaks are constructed in areas where winter weather is severe. It is important to realize that drylot housing does not allow the luxury of managing the risks that Mother Nature can present in the form of rain, snow, and severe windchill. The advantage of drylot facilities is the lower capital investment per cow as compared to freestall housing.

Freestall housing usually is selected to minimize the effect of weather changes and to improve cleanliness and cow comfort. Providing a clean dry bed is essential to minimize the incidence of mastitis in the herd. Comfort refers to providing a comfortable bed and the correct freestall dimensions. This makes it easy for the cow to move in and out of the stall and to lie comfortably in the stall. The disadvantages of freestall housing are the costs of construction and of maintaining the beds.

Selecting and Locating Freestall Barns

Several options are available when selecting freestall housing for lactating dairy cows. Some of the options include 2-row, 3-row, 4-row, or 6-row freestall barns. Access to feed is reduced by 11 inches per cow (Table 6) in 3- and 6-row barns compared to 2- and 4-row barns. The heat load per stall is greater in 3- and 6- vs 2- and 4-row barns at stocking rates of 100 to 130%. The advantage of 2- or 4-row freestall barns is access to feed, more sq ft per cow, and a lower heat load per stall. The advantage of 6-row barns is cost; however, producers should be concerned about the level of heat stress and the limited feeding area. Providing supplemental cooling in 6-row barns may be more critical because of the reduction in sq ft per stall.

Table 7. Available Feedline Space, Square Footage, and Heat Produced by Cows in Different Styles of Freestall Barns[1]

Barn Style	Pen Width	Pen Length (ft)	# Stalls	Sq Ft/ Cow	Feedline Space	BTU'S/ Cow/ hr	Stocking Percentage (cows/stalls) 100% BTU's/ sq ft	110% BTU's/ sq ft	120% BTU's/ sq ft	130% BTU's/ sq ft
4-Row	39	240	100	94	29	4500	48	53	58	63
6-Row	47	240	160	71	18	4500	64	70	77	83
2-Row	39	240	100	94	29	4500	48	53	58	63
3-Row	47	240	160	71	18	4500	64	70	77	83

[1]Based on a cow weighing 1500 pounds and producing 70 pounds of milk per day.

Ventilation and Orientation of Freestall Barns

Proper ventilation is essential in a freestall barn. Freestall housing should be constructed to provide good natural ventilation. Sidewalls should be 12 to 14 ft high to increase the volume of air in the housing area. The sidewalls should have the ability to open 75 to 100%. Fresh air should be introduced at the cow's level. Curtains on the sides of freestall barns allow greater flexibility in adjusting the environment around the cow. Because warm air rises, steeper-sloped roofs provide upward flow of warm air. Roof slopes for freestall housing with gable roofs should be 4/12. Gable roofs with slopes less than 4/12 may have condensation and cause higher internal temperatures in the summer. Providing openings on the end walls in addition to alley doors will improve summer ventilation. Gable buildings should have a continuous ridge opening to allow warm air to escape. The ridge opening should be 2 inches for each 10 ft of building width. Naturally ventilated buildings should have a minimum of 100 ft between structures. Freestall barns typically are oriented east to west to take advantage of sun angles and provide afternoon shade. Producers who construct barns north to south will find an overhang on the west side desirable to produce shade for stalls on that side of the barn during the afternoon. Freestall barns should be located within recommended walking distances to the milking center but not so close that natural ventilation is restricted.

Walking Distance

Facilities need to be sited to minimize the distance cows have to walk to and from the milking parlor. A forced walk in drylot housing would be from the gate of the housing area to the gate of the holding pen. Field observations in drylot facilities indicate that the maximum forced walking distance should be a 1000 ft for 2× milking, 700 ft for 3× milking, and 500 ft for 4× milking in drylot dairies. Field observation in freestall building reveals that cows begin to bunch up about halfway through the pen. It is not known if this bunching causes additional stress as compared to cows exiting drylot housing. So at this time, we estimate the forced-walk distance in freestall barns as one half of the alley length plus the distance from the top of the pen to the holding pen. Information is needed to establish the maximum forced walk in freestall barns.

Cow Traffic Lanes

The width of cow traffic lanes should be sized according to group size. When group size is less than 200 cows, 14-ft traffic lanes typically are used. Lane width is increased to 16 ft for group sizes from 200 to 300 cows and to 20 ft when group size is greater than 350 cows.

Water Availability

High-producing dairy cows can consume between 30 to 50 gal of water per day. Water should be provided to cows leaving the milking parlor. In parlors that are double 25's or smaller, one 8-ft trough is usually sufficient. In parlors larger than double 25's, two 8-ft troughs commonly are used. In freestall housing, water should be located at every crossover. There should be one waterer or 2 ft of tank perimeter for every 10 to 20 cows. In drylot housing in the southwest U.S., the following formula has been used to calculate the needed tank perimeter:

Group size × .15 × 2 = tank perimeter in feet

The water system must be able to provide 75 to 100 gal per cow per day. Peak flow rate is determined by number of waterers, assuming 100% utilization or milk parlor usage during cleaning. A minimum size well is probably 10 gal per min (gpm) per 100 cows with 20 to 30 gpm per 100 cows being preferred.

How Many Crossovers Do I Need?

Recommended distances between crossovers range from 60 to 160 ft. A good rule of thumb is to provide crossovers every 100 feet, or every 25 stalls. Crossovers are typically 10 to 12 ft wide. However, if a waterer is located in the crossover, consider increasing the width to 14 ft to allow cows to pass easily behind cows that are drinking. Producers often reduce the number of cross overs in freestall barns to reduce construction costs. However, very few producers stock feestall barns at one cow per stall. The tendency is to overstock them. Therefore, reducing the number of crossovers or the width of crossovers restricts access to feed and water, and limits the space for cows at the feed line. The bottom line is that the cows suffer when the number of crossovers is reduced.

Recommended Stall Dimensions

The dimensions used for constructing freestall area is a compromise between cow comfort and cow cleanliness (Table 8). The challenge is to construct stalls that make it easy for cows to lie down and get up naturally and comfortably, while positioning the cow to urinate and defecate in the alley. Stalls should be wide enough that cows normally do not bump or push on stall partitions in any way when rising or lying. But, stalls that are too wide may allow cows to turn around or lie diagonally. Stalls that are too long may allow lying too far forward unless brisket boards are used. All of these conditions increase the possibility of manure being deposited on the stall bed and dirty bedding. In hot climates, consideration to heat buildup in the freestall area may lead to wider (48 inches) and longer (8 ft) freestalls.

With two rows of freestalls placed head-to-head and designed for space-sharing, stall partitions usually are mounted on individual posts to allow for unrestricted open space for the forward lunge into the adjacent stall space.

It is important that building support posts are located at multiples equivalent to stall width. This will prevent building support post from obstructing the lunge space. Freestall width should determine building post spacing, not vice versa.

Table 8. Suggested Freestall Dimensions[1]

Weight, lb	Free Stall Width[2], inches	Free Stall Length[2], inches		Neck Rail Height above Stall Bed, inches	Neck Rail and Brisket Board Distance from Alley Side of Curb, inches
		Side Lunge	Forward Lunge		
800-1,200	42 to 44	78	90 to 96	37	62
1,200-1,500	44 to 48	84	96 to 102	40	66

[1]Width: "center-to-center" with 2-inch pipe partitions. Length: alley side of the curb to the front of the stall.
[2]Adapted from the Bickert and Smith (1998).

Grouping Strategies

The size and number of cow groups on a dairy are critical planning factors. Factors affecting the number and types of groups are largely associated with maximizing cow comfort, feeding strategies, reproduction, and increasing labor efficiency. Lactating cows (100%) are allotted to each of four groups; healthy (92%), fresh (4%), sick (2%), or slow milkers and lame (2%). Healthy cows should account for 92% of the total number of lactating cows and typically are divided into eight groups. Group size is determined by the size of the parlor and milking frequency.

Observations on commercial dairies indicate that a group should be milked in 60 min when milking 2× per day; 40 min when milking 3× per day; and 30 min when milking 4× per day. This will prevent the cows from being kept away from feed and water for more than 2 hrs per day. Within the eight groups of healthy lactating cows, individual cows are assigned to pens based on nutritional requirements, reproductive status, and social factors.

First, heifers respond favorably when grouped separately from older cows. Heifers have lower dry matter intakes and greater growth requirements than older cattle. In addition, mixing heifers with older cattle increases social pressure, resulting in less than optimal heifer performance. Heifers should be kept in separate groups and divided based on reproductive status. Heifers could be grouped as open-not breeding, breeding, and pregnant. This increases labor efficiency during breeding by concentrating all breeding activities to one pen. The remaining healthy lactating cows are allotted to groups by reproductive status and nutritional needs. Nutritional requirements for these groups vary, and as above, concentrating breeding activities maximizes labor efficiency. One disadvantage to the above grouping scheme is the need to move cows from pen to pen.

Movement of cattle increases labor requirements and disrupts the social order in a pen. Usually, 3 to 4 days are required to reestablish social order when cattle move to a new pen. The results are reduced feed intakes and lost milk production. Therefore, some producers have chosen to freshen cows as a group and maintain the group throughout lactation. Rather than moving the cows to correct diet or management area, this strategy brings the diet and management to the cow. The difficulty in this system is calving enough cows to fill a pen in less then 30 days.

In addition to the healthy lactating cows, some of the lactating cows will have special requirements. Separating fresh, sick, and lame or slow milking cows increases parlor and treatment labor efficiency as well as reducing stress on the cattle. Fresh cows will account for 4% of the healthy herd size assuming that the number of calvings annually is 115% of lactating cows. The fresh cows should be housed in a loose housing pen for 10 days. Provisions must be made to segregate non-salable milk. Careful attention to intake, milk production, health, and cow comfort is necessary for cattle in this pen to prosper. The sick pen should handle 2% of the healthy lactating cows. Removal of sick cattle from the healthy pens is necessary for efficient treatment, to prevent antibiotic contamination of milk, and increase cow comfort. Fresh and sick pens should be bedded with sand to maximize cow comfort. Lame and slow milking cows often are housed in the same pen and located close to the milking parlor. Removing slow moving or slow milking cows from the other pens will increase parlor efficiency 8 to 10%. Lame or slow milking cows will be about 2% of the healthy lactating cows and can be housed in freestalls.

On large dairies, nonlactating cattle should be divided into five groups defined as maternity, overconditioned dry cows, underconditioned dry cows, close-up dry cows, and close-up heifers. Nutritional needs of these groups vary greatly, and grouping of these heifers and cows according to nutritional requirements is critical to minimize subsequent metabolic problems associated with calving. Ideally, cows calve in individual maternity pens. Close attention to close up pens allows cows that are just beginning the calving process to be moved to the calving pens. Cows normally stay in the maternity pen less than 24 hours. The number of maternity pens needed is approximately equal to .33% of the total milking cows. Dry cows and springing heifers differ in nutritional requirements. Dry cows have greater intakes and are much more likely to develop milk fever than heifers. Springing heifers also may benefit from a longer transition period than normally allowed for cows. Thus, heifers and dry cows should be separated.

Dry cows more than 21 days from calving should separated into two groups, based on body condition. Cows lacking adequate body condition benefit from additional energy during the dry period, whereas feeding extra energy to adequately conditioned cows may be detrimental. Dry cows within 21 days of calving should be moved to a close up pen. The diet in this pen should have greater concentrations of protein and energy than the far off dry cow diet. In addition, the diet should be low in calcium and potassium or contain anionic salts with appropriate amounts of calcium and potassium to prevent milk fever. Milk fever is generally not a problem with heifers, but they may benefit from receiving the typical transition diet for 5 weeks rather than 3 weeks. Thus, feeding a diet fortified with protein and energy without anionic salts for 5 weeks prior to freshening would be beneficial for heifers.

These plans do not include a quarantine area. True quarantine pens should be located away from this facility. If a true quarantine period were desired, springing heifers would need to be received at another facility, at least 1 month prior to moving to this facility. In general, this is not the typical practice. Thus, the overflow pen will generally be utilized as the receiving pen for replacement heifers. Examples of preliminary sizing are presented in Table 9.

Table 9. Preliminary Sizing of Dairy Facilities with Different Parlor Sizes[1]

Item	Approx. % of Milk Herd	Double 10	Milk Parlor Size Double 20	Double 30	Double 40	Double 50
Steady state throughput[2]		90	180	270	360	450
Total lactating cows	100	600	1,200	1,800	2,400	3,000
Milking group size[3]		70	140	210	280	350
Healthy lactating cows	92	560	1,120	1,680	2,240	2,800
Sick cows[4]	2	10	20	35	45	60
Fresh	4	20	40	70	90	120
Slow milking or lame cows	2	10	20	35	45	60
Maternity	0.33	2	4	6	8	10
Dry cows and heifers	25	150	300	450	600	750
Freshened cows per year	115	690	1,380	2,070	2,760	3,450
Over-conditioned dry cows	5	30	60	90	120	150
Under-conditioned dry	5	30	60	90	120	150
Close-up dry cows	5	30	60	90	120	150
Close-up heifers	5	30	60	90	120	150
Close-up - overflow pen	5	30	60	90	120	150

[1]Design based on 3× milking, 6.5 hours of steady throughput, 1.5 hours for parlor turn time (maintenance, clean up, etc). [2]Milk parlor performance is based on steady-state throughput at 4.5 turns per hour. [3]Milk groups based on 8 groups of cows with a milking time per group of 45 minutes and rounded to accommodate the parlor. [4]Assumes the sick, fresh, and slow milking or lame cows will be milked in the same parlor during a 1.5 hour turnaround period.

Site Evaluation and Selection

Preliminary site evaluation includes land availability for the facilities, crop production, and manure disposal. Generally, land for crop production and manure application is rented or owned by a partner. Immediate and future environmental consideration suggest that 1 to 2 cows per acre of land would be required for manure application. This is based on phosphorus being the limiting nutrient, which likely becomes the standard in most areas. Currently, many use 5 to 10 cows per acre, but the potential exists for excessive nutrients, primarily phosphorus and potassium, being applied to the land unless a crop consultant is used to monitor nutrient accommodation. Other factors such as waterways, separation distances, and neighbors may limit the area where manure can be applied.

The facilities, buildings, feed center, and waste management system will require approximately 1 acre per 75 to 100 cows. Initial site evaluation must consider the availability of three-phase electricity, water accessibility, and sewer (manure storage and handling). If any one of these items appears cost prohibitive or not feasible to achieve, another site should be considered. Other factors to consider include:

- Access by milk and feed trucks
- Separation distance from other buildings for good natural ventilation
- Prevailing wind direction (affects ventilation and odor problems)
- Distance from neighbors and town, surrounding land use
- Distance from all surface water (rivers, streams, lakes, and wetlands)
- Soil type (affects waste management)
- Depth to water table and bedrock
- Drainage and slope
- Availability and quality of the water supply, and
- Availability of cropland for utilization of manure nutrients.

The layout of the complete dairy operation will be determined based on plans for:

- Freestall barns (e.g., number of groups, stall layout)
- Milking center
- Treatment and maternity facilities
- Dry cow, close-up dry cow, and fresh cow facilities
- Calf and heifer housing (if needed)
- Handling and storage of manure and milking center wastewater
- Collection and storage of runoff from outside lots, and
- Storage facilities for corn silage, haylage, dry hay, or commodity feeds

Complete plans for waste handling, storage, and land application must be developed by a consulting engineering and dairy design team.

All regulatory agencies must approve the plans before any construction begins (e.g., health department, milk inspector, designated manure regulatory agency, or local government).

Manure Management

Dairies will generate 2 to 3 lb of manure and wastewater per lb of milk produced. Most dairies use a flush system to transport the manure from the alleys, pens, or housing area to the storage area. Experiences in Kansas suggest that flushing wave velocity needs to be 7.5 to 10 ft/second with a 20 second contact time to adequately flush alleys alongside of sand-bedded freestalls. Flushing is improved by sloping the buildings 2 to 3%. Freestalls bedded with sand use an average of 50 lb of sand per cow per day. Dairies are experimenting with gravity and mechanical sand separators to reclaim the sand. Gravity systems generally require stockpiling of the reclaimed sand 6 to 12 months prior to reuse or blending with clean sand.

The manure and effluent generally are stored in a solids storage basin and liquid storage lagoon. These structures have to meet state or federal guidelines or both. The solid storage basin normally is built as economically as possible. However, this may not be the most cost-effective decision. Operations that have weekly or monthly hauling invariably will keep cropland out of production to have adequate land available for solid manure disposal. Cropping practices should be considered during the design stage. Effluent from lagoons is applied to growing crops, if possible. This requires having adequate land available to install irrigation equipment for maintaining storage volume. Stockpiling on berms or at the edge of fields to provide additional storage space results in additional handling and containment structures to control nutrients leaching from the stockpile area.

Putting the Pieces Together

This article presented some of the issues concerning planning an expansion or relocation. Its focus was on facility issues that influence cow productivity and labor efficiency. Space is not sufficient to include detailed information on the layout of the feed center, replacement heifer housing, and the manure management system. The design and layout of these two components are critical to ensure that the dairy runs smoothly. It is essential that a consulting engineer be used to design all components of a dairy.