Relocation and Expansion Planning

By J.F. Smith, Kansas State University
J.P. Harner III, Kansas State University
M.L. Brouk, Kansas State University
D.V. Armstrong, University of Arizona
M.J. Gamroth, Oregon State University
M.J. Meyer, Kansas State University

Western Dairy Management Conference

Relocation & Expansion Planning

Relocating or expanding a dairy facility is process that requires a tremendous amount of time and planning. Owners or managers of dairies will go through a number of steps including:

- *Developing a Business Plan*
- *Design Process*
- *Developing Specifications*
- *Selecting Location/Site*
- *Permitting/Legal*
- *Obtaining Bids*
- *Selecting Contractors*
- *Buying Cattle*
- *Purchasing Feeds*
- *Financing*
- *Managing Construction*
- *Hiring & Training Employees*
- *Developing Management Protocols for the Dairy.*
- *Information Flow*

These proceedings will discuss designing and locating a dairy facility based on labor efficiency and maximizing cow performance. The dairy can be divided into these components; 1) milking parlor 2) cow housing 3) special needs facility (hospital, closeups, etc.) 4) manure management system and 5) feed center. We will center our comments in this publication to milking parlors, cow housing, grouping strategies, and site selection.

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 dairy management employs a dairy design consultant to work with the dairy management specialist in developing a basic dairy design and program plan to meet the clientís needs. The design team consists of a consulting engineer and supporting dairy management specialists. Dairy management specialists 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 (Bugger et al., 1994, Welchert et al., 1994).

Options for the Milking Parlor

Evaluating Parlor Performance

Milking parlor performance has been evaluated by time and motion studies (Armstrong et al., 1986) 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, pre-milking hygiene, number of operators and construction. Examples of different management techniques that affect parlor performance are listed below (Armstrong et al., 1992 and 1994):

- Data collected in parallel milking parlors indicates that milking cows 3x per day, versus 2x per day, increases throughput 8-10 percent.
- The use of detachers does not increase throughput with the same number of operators.
- The use of pre-dip milking hygiene reduces parlor performance 15-20 percent.
- The average number of cows milked per operator hour decreases as the number of operators increases from one to four.
- Steady-state throughput is 10-12 percent higher in new parlors than in renovated parlors.

Table 1: Design Criteria for Parallel and Herringbone Parlors.

milking frequency	shift length	turns per hour
2x	8.0	4.0
3x	6.5	5.0
4x	5.0	6.0

Sizing Parallel & Herringbone Milking Parlors

In Table 1, the design criteria for parallel and herringbone parlors is presented.

Typically, milking parlors are sized so that cows can be milked once in 8 hours when milking 2x per day; 6.5 hours when milking 3x per day; and 5 hours when milking 4x per day. Using these criteria, the milking parlor will be sized to accommodate the cleaning and maintenance of the parlor. The facilities or cow groups are determined based on milking one group in 60 minutes when milking 2x, 40 minutes when milking 3x, and 30 minutes when milking 4x. Group size is slightly adjusted 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:

Table 2: Rotary Parlor Performance (Cows per hour)

time	---------------------- theoretical cows/hr. ----------------------				
(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

Total # of stalls x 4.5 = cows milked per hour (CPH)

Of milking cows = CPH x milking shift length (hours)

Sizing Rotary Parlors

Entry time (seconds/stall), number of empty stalls, number of cows which 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

Table 3: Rotary Milking Parlor Performance on Commercial Dairies

number of stalls	entry per cow (secs.)	pre-milking hygiene	theory* cows/hr.	milking freq.	actual cows/hr.	# of operators	cows labor/hr.	% of actual theory	milk** prod.
32	15:00	wipe-strip	240	2x	195	2	98	81%	57[a]
36	15:00	wipe	240	3x	187	1	187	78%	78
40	11:00	wipe-strip	320	2x	288	2	144	90%	56[b]
40	13:00	wipe-strip	276	2x	245	2	123	89%	56[b]
40	15:00	wipe	240	4x	203	1.5	135	85%	80
40	15:50	full	232	3x	188	4	47	81%	62
40	14:40	wipe-strip	250	3x	205	2	103	82%	65
48	10:00	none	360	2x	263	2	132	74%	60
48	10:00	none	360	2x	279	2	140	78%	59
48	8:80	none	409	2x	251	2	126	61%	60
48	10:25	strip	351	3x	309	3.3	94	88%	66
60	8:00	full	450	3x	336	5	67	75%	65
60	7:80	strip	462	2x	283	5	57	61%	57
72	6:60	strip	545	2x	440	4	110	81%	63
avg.	11:45		338		262		112	79%	64

** Steady state throughput*

*** lbs of milk per cow per day*

[a] *Jerseys and Guernseys*

[b] *Jerseys*

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 / 10 seconds per stall = 360 cows per hour). This is referred to as theoretical throughput.

Theoretical throughput assumes that the parlor never stops, cows are milked out in 1 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 increases the percent of theoretical throughput is decreased.

Data collected on 14 dairies (Table 3) with recently constructed new rotary parlors had an average rotation time of 11:45 seconds and the throughput averaged 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 percent of the cows to be milked out in one trip around the parlor.

In reviewing the data available today, rotary parlor should be sized at an 11-12 sec/stall rotation and 80% of theoretical throughput. The parlor should be large enough to allow 9 minutes of available unit on time.

Selecting Parlor Type

Currently, herringbone, parallel, and rotary parlors are the three predominant types of parlors constructed on large dairies today. Earlier research would indicate that similar sized parallel parlors out-performed herringbone parlors (Armstrong et al., 1989 and Thomas, 1994).

Recently, there has been a renewed interest in rotary parlors. In Table 5 performance data from 33 parlors is presented by type, size, and pre-milking hygiene. Throughput and cows/labor hour is reduced when a full pre-milking hygiene is used. Additional information is needed in rotary parlors with a full pre-milking hygiene since we only have data on 2 Rotaries with a full pre-milking hygiene.

The square footage required to house the milking parlor is influenced by parlor type. In Table 6 the estimated square footage of the milk parlor has been determined for different sizes of parallel and rotary milking parlors. The square footage requirement for parallels range from 1890 to 5300 sq. ft while the square footage requirement for rotary parlors ranges from 3,025 to 9,216 sq. ft. Producers need to

Table 4: Available Unit On Time Calculated for Rotary Parlors at Different Rotation Times*

		(Revolution Time)		(Available Unit on Time)	
number of stalls	entry time sec./stall	secs. per revolution	minutes per rev.	secs. per revolution	minutes per rev.
40	8	320	5:20	240	4:00
	10	400	6:40	300	5:00
	12	480	8:00	360	6:00
	15	600	10:00	780	7:30
60	8	480	8:00	400	6:40
	10	600	10:00	500	8:20
	12	720	12:00	600	10:00
	15	900	15:00	750	12:30
72	8	576	9:22	496	8:16
	10	720	12:00	620	10:20
	12	864	14:24	744	12:24
	15	1080	18:00	930	15:30
80	8	640	10:40	560	9:20
	10	800	13:20	700	11:40
	12	960	16:00	840	14:00
	15	1500	20:00	1050	17:30

**Assumes 5 stalls for entry and exit, 3 stalls for pre-milking hygiene, 2 stalls to detach and post dip.*

Table 5: Milking Parlor Performance on Commercial Dairies using Herringbone, Parallel and Rotary Parlors using Different Pre-Milk Hygiene

parlor type	total # of stalls	# parlors observed	pre-milk hygiene[a]	cows/hr.*	# of operators	cows per labor/hr.
40 Rotary	40	1	Full[c]	188	4.0	47
Double 25 Parallel	50	2	Full[c]	231	4.0	58
60 Rotary	60	1	Full[c]	336	5.0	67
Double 30 Parallel	60	1	Full[c]	272	3.0	91
Double 32 Parallel	64	1	Full[c]	268	3.0	89
Double 35 Parallel	70	1	Full[c]	280	2.5	112
Double 40 Herringbone	80	1	Full[c]	392	7.0	56
Double 40 Parallel	80	1	Full[c]	385	4.0	96
Double 45 Parallel	90	3	Full[c]	396	5.0	79
Double 50 Parallel	100	1	Full[c]	460	5.0	92
32 Rotary	32	1	Min[b]	195	2.0	98
36 Rotary	36	1	Min[b]	187	1.0	187
40 Rotary	40	4	Min[b]	235	1.9	124
48 Rotary	48	3	Attach[a]	264	2.0	132
48 Rotary	48	1	Min[b]	309	3.3	94
Double 28 Herringbone	56	1	Min[b]	252	3.0	84
60 Rotary	60	1	Min[b]	283	5.0	57
Double 30 Parallel	60	2	Min[b]	280	3.0	93
Double 35 Parallel	70	1	Min[b]	352	3.0	117
72 Rotary	72	1	Min[b]	440	4.0	110
Double 40 Herringbone	80	1	Attach[a]	408	4.0	102
Double 40 Parallel	80	1	Min[b]	491	4.0	123
Double 50 Parallel	100	2	Min[b]	609	5.0	122

** Steady state throughput*
[a] *Attach units*
[b] *Strip, attach or wipe, strip and attach*
[c] *Strip, pre-dip, wipe, attach*

Table 6. Estimated Square footage requirements for rotary and parallel milking parlors.

total # of stalls	parlor type	platform length or diameter (feet)	parlor (feet)	parlor (feet)	bldg. area (sq. ft.)	ratio of sq. 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

compare the construction cost of the different parlor types they are considering.

If constructing the parlor shell, cost $35/sq. ft., a D-40 parallel shell would cost $184,400 and an 80 stall rotary shell $322,560. Equipment dealers are estimating 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. The operator pit can be constructed in parallel and herringbone parlors to allow additional stalls to be added as the dairy expands.

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. As you can see, deciding what type and size of parlor to build is very complex decision for a dairy operator.

One vs. Two Parlors

Some research indicates that two smaller parlors are more efficient than one larger parlor (Thomas et al. 1993,1994,1995). One study compared two double-20 parallels versus one double-40 parallel (Thomas et al.1995). 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 2 parlors also allows producers to construct the dairy in phases.

Holding Pens

Holding pens are designed based on 15 square feet per cow with a minimum capacity of one group of cows. When a wash pen is not used, oversizing the holding pen by 25 percent allows a second group to be moved into the holding pen while the crowd gate is pulled forward and the first group is finishing being milked (Smith et al., 1997).

Wash Pen Design

The design and management of the wash pen is very important in Western US 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 will depend upon several factors:

1.) If the wash pen is at a ninety-degree angle to the cow traffic lane, additional area is necessary to allow the cows to properly fit in to the wash pen.

2.) As group size increases, the area per cow increases. With group sizes up to 200 cows, a wash pen of 15 square feet per cow is adequate. With groups above 200 cows, 16-17 square foot per cow will provide adequate space.

Design of the sprinkler system is essential 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-foot by 6-foot grid. For example, a 40-foot wide holding pen with outside rows 2 feet from the side walls would have 5 rows of sprinklers spaced 6 feet apart and 5 feet top to bottom.

Use a three-stage timer to operate the sprinklers. The timings will effect 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 gallons 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 two minutes of stand time is adequate. The third cycle is a three-minute wash period. If cows are still dirty, wait one minute and wash for three minutes again. During the stand time cows will move into new positions which will improve wash pen efficiency.

Drip Pen Design

Drip pen area of 15 square foot per cow will be adequate. Size the drip pen to hold 100% of the corral or group size. This allows 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 D-20 should have a minimum size to hold 80 cows (1200 square feet). This would allow 24-30 minutes from the time in the wash pen to parlor entry.

Exit Lanes

Exit lane width is dependent on the number of stalls on one side of the milking parlor. In parlors with 15 stalls or less per side, a clear width of 3 feet is acceptable. For parlors containing more than 15 stalls per side, a clear exit lane width of 5 to 6 feet is desired (Smith et al., 1997).

Operator Pits

Operator pits are typically 8 feet wide between curbs. The cow platform is 38-40 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 inches. Normally, the operator pit and cow platform should have a 1-percent 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 (Smith et al., 1997).

Constructing the Milking Parlor Shell

There are several options 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 is often 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 properly ventilated to maintain employee and cow comfort. Office, meeting room, break room and rest room facilities should be incorporated to meet the needs of management (Smith et al., 1997).

Selecting Cow Housing

The predominant types of cow housing in the Western United States are drylots and freestalls. This decision 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 (Sweeten et al.1993). However, frequency and severity of winter rainfall and blizzards is becoming the key selection criteria. These facilities would provide 500-700 square feet per lactating cow depending on the evaporation rate and 40 square feet 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 managers the luxury of managing the risk Mother Nature can present in the form of rain, snow and severe wind-chill. The advantage of drylot facilities is the lower capital investment per cow as compared to freestall housing.

Freestall housing is usually selected to minimize the effect of weather changes, 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 disadvantage of freestall housing is the cost of constructing freestall housing and the costs associated with 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 when 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 100-130%. The advantage of 2-row or 4-row freestall barns is access to feed, more square feet per cow, and a lower heat load per stall in the barn. 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 due to the reduction in square feet per stall.

Table 7: Available Feedline Space, Square Footage and Heat Produced by Cows in Different Styles of Freestall Barns*

							(stocking percentage [cows per stall])			
barn style	pen width (ft.)	pen length (ft.)	# of stalls	square ft./cow	feedline space	BTUs cow/hr.	100% BTUs/stall	110% BTUs/stall	120% BTUs/stall	130% BTUs/stall
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

**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 12-14 ft high to increase the volume of air in the housing area. The sidewalls should have the ability to open 75-100 percent. 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. Since 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 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 in for each 10 ft of building width. Naturally ventilated buildings should have a minimum of 100 ft between structures. In the Midwest, freestall barns are typically 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 the west side of the barn during the afternoon. Freestall barns should be located within recommended walking distances to the milking center but not restrict natural ventilation.

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 would indicate the maximum forced walking distance should be a 1000 ft for 2x milking, 700 ft for 3x milking and 500 ft for 4x milking in drylot dairies. Field observation in freestall building reveals 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 would figure 1/2 alley length plus the distance from the top of the pen to the holding pen as forced walk distance in freestall barns. Information is needed to establish the maximum forced walk in freestall barns.

Water Availability

High producing dairy cows can consume between 30-50 gal of water per day. Water should be provided to cows leaving the milking parlor. In parlors which are double-25ís or smaller, one 8-ft trough is usually sufficient in parlors larger than double-25ís, two 8-ft troughs are commonly used. In freestall housing, water should be located at every crossover. There should be one waterer or 2 ft of tank perimeter for every 10-20 cows.

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

How Many Crossovers Do I Need?

Crossovers should be provided every 120-160 ft, or every 30-40 stalls. Crossovers are typically 10-12 feet wide. However, if a waterer is located in the crossover, consider increasing the width to 14 feet to allow cows to easily pass behind cows which are drinking. Producers often reduce the number of crossovers in freestall barns to reduce construction costs. Reducing the number of crossovers limits the cow's access to feed and water. It also reduces the total length available to construct the feedline.

Very few producers stock freestall barns at 1 cow per stall. The tendency is to overstock freestall facilities. 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 freestalls area 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 feet) freestalls.

With two rows of freestalls placed head-to-head and designed for space-sharing, stall partitions are usually 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.

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 one 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 are typically divided into 8 groups. Group size is determined by the size of the parlor and milking frequency.

Observations on commercial dairy tours would indicate that a group should be milked in 60 minutes when milking 2x per day; 40 minutes when milking 3x per day; and 30 minutes when milking 4x per day. This will prevent the cows from being kept away from feed and water to no more than 2 hours per day. Within the 8 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 as compared to 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

Table 8: Suggested Freestall Dimensions**

weight (lbs.)	freestall width (in.)*	(freestall length, inches*) side lunge	forward lunge	neck rail height above stall bed (in.)	neck rail & brisket board distance from alley side of curb (in.)
800-1,200	42-44	78	90-96	37	62
1,200-1,500	44-48	84	96-102	40	66

** Width: "center-to-center" with 2-in pipe partitions. Length: alley side of the curb to the front of the stall.*

*** Adapted from the Bickert & Smith, 1998* 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, 3-4 days are required to reestablish social order when cattle move to a new pen. The result is reduced feed intakes and lost milk production. As a result, 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, 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 the sick cattle from the healthy pens is necessary for efficient treatment, to prevent antibiotic contamination of milk, and increase cow comfort. It is recommended the fresh and sick pens be sand bedded loose housing regardless of housing type to maximize cow comfort. Lame and slow milking cows are often 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 and slow milking cows will be about 2% of the healthy lactating cows and can be housed in freestalls.

On large dairies, non-lactating cattle should be divided into 5 groups defined as maternity, over conditioned dry cows, under conditioned 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 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 may also 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 in body condition benefit from additional energy during the dry period, while 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 as compared to the other 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 heifers 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 one 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*

	Approx. % of Milk Herd	dbl-10	dbl-20	dbl-30	dbl-40	dbl-50
		(Milking Parlor Size)				
Steady state throughput**		90	180	270	360	450
Total lactating cows	100	600	1,200	1,800	2,400	3,000
Milking group size***		70	140	210	280	350
Healthy lactating cows	92	560	1,120	1,680	2,240	2,800
Sick cows****	2	10	20	35	45	60
Fresh	4	20	40	70	90	120
Slow milkers & lame cows	2	10	20	35	45	60
Maternity	0.33	2	4	6	8	10
Dry cows & 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 cows	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

** Design based on 3x milking, 6.5 hours of steady throughput, 1.5 hours for parlor turn time (maintenance, clean up, etc).*
*** Milk parlor performance is based on steady state throughput at 4.5 turns per hour.*
**** Milk groups based on 8 groups of cows with a milking time per group of 45 minutes and rounded to accommodate the parlor.*
***** Assumes the sick, fresh, slow milkers and lame cows will be milked in same parlor during 1.5 hour turn around 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 would suggest 1-2 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 5-10 cows per acre, but the potential exists for excessive nutrients, preliminary 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, neighbors, etc., may limit the area where manure can be applied.

The facilities, buildings, feed center, and waste management system will require approximately 1 acre per 75-100 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 four items appears cost prohibitive or not feasible to obtain, another site should be considered. Martin (1998) notes other factors to consider include:

- Access by milk and feed trucks
- Separation distance from other buildings for good natural ventilation
- Prevailing wind direction (effects ventilation and odor problems)
- Distance from neighbors and town, surrounding land use
- Distance from all surface water (rivers, streams, lakes, and wetlands)
- Soil type (effects waste management)
- Depth to water table and bedrock
- Drainage and slope
- Availability and quality of the water supply
- Availability of cropland for utilization of manure nutrients.
- The layout of the complete dairy operation will be determined based on plans for:
  a. freestall barns (number of groups, stall layout, etc.)
  b. Milking center
  c. Treatment and maternity facilities

d. Dry cow, close-up dry cow, and fresh cow facilities
e. Calf and heifer housing (if needed)
f. Manure and milking center wastewater handling and storage
g. Collection and storage of runoff from outside lots, and
h. Storage facilities for corn silage, haylage, dry hay, commodity feeds, etc.

- 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, (health department, milk inspector, designated manure regulatory agency, local government, etc.).

Manure Management

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

The manure and effluent are generally stored in a solids storage basin and liquid storage lagoon. These structures have to meet state and/or federal guidelines. The solid storage basin is normally built as economical as possible. However, this may not be the most cost-effective decision. Operations, which have weekly or monthly hauling will invariably, have to 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 normally applied to growing crops if possible. This requires having adequate land available to install irrigation equipment for maintaining storage volume. Stock piling 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

In these proceedings we have discussed some of the issues concerning planning an expansion or relocation. We focused our efforts on facility issues that influence cow productivity and labor efficiency. We did not have the space in this publication to include detailed information on the layout of the feed center and waste management system. The design and layout of these two components are critical to insure that the dairy runs smoothly. Seek advice when expanding these components of an operation.

References:

1. Armstrong, D.V. and A.J. Quick. 1986. Time and motion to measure milk parlor performance. J. Dairy Sci. 69(4): 1169-1177.

2. Armstrong, D.V., Gamroth, M.J., Welchert, W.T., and F.W. Wiersma. 1989. Area Parallel Parlors the Parlors of the Future? In Proc. of Intíl. Stockmanís School, San Antonio, TX.

3. Armstrong, D.V., J.F. Smith, and M.J. Gamroth. 1992. Parallel parlor efficiency as related to number of operators, construction, milking interval, and automatic detachers. J. Dairy Sci. 75(Suppl. 1):351(Abstr).

4. Armstrong, D.V., J.F. Smith, and M.J. Gamroth. 1994. Milking parlor performance in the United States. In Dairy Systems for the 21st Century. Proc. of the 3rd Int'l. Dairy Housing Conf., 59-69. St. Joseph, Mich.: ASAE.

5. Bickert, W.G. and J.F. Smith. 1998. In Proc. of Midwest Dairy Management Conference, 108-117, Minneapolis, MN.

6. Brugger, M. F., and J. L. Wille. 1994. Using design assistance for planning the modern dairy facility. Page 539 in Dairy Systems for the 21st Century. Am. Soc. Agric. Eng. No. 02-94, Am. Soc. Agric. Eng., St. Joseph, MI.

7. DeLorenzo, M.A., G.R. Bryan, D.K. Beede, and

J.A.M. Van Arendonk. 1989. Integrating management models and databases: I. Optimizing model for breeding, replacement, seasonal production, and cash flow. J. Dairy Sci. 72(Suppl. 1):448(Abstr).

8. Fulhage, C.D., and J.A. Hoehne. 1998. Performance of a Screen Separator for Flushed Dairy Manure. In Proc. of the 4th Int'l. Dairy Housing Conf, 130-135. St. Louis, MO.: ASAE.
9. Martin, J.G., III, PE. 1998. Siting Large Dairy Facilities. In Proc. of the 4th Int'l. Dairy Housing Conf., 29-36. St. Louis, MO. :ASAE.
10. Smith, J.F., Armstrong, D.V., Gamroth, M.J., and J.G. Martin. 1997. Planning the Milking Center in Expanding Dairies. Journal of Dairy Science 80:1866-1871.
11. Smith, J.F., D.V. Armstrong, and M.J. Gamroth. 1995. Planning the milking center. MF-2165. Cooperative Extension Service Publication. Manhattan, Kans.: Kansas State University.
12. Smith, J.F., D.V. Armstrong, M.J. Gamroth, and J. Harner III. 1998. In Proc. of the 4th Int'l. Dairy Housing Conf., 88-95. St. Joseph, MI.: ASAE.
13. Sweeten, J.M. and M.L. Wolfe. 1993. Manure and Wastewater Management Systems for Open Lot Dairy Operations. In Proc. of Western Large Herd Management Conference, Las Vegas, NV.
14. Thomas, C.V. 1994. Operations and economic models for large milking parlors. Ph.D. diss. Gainesville, Fla.: University of Florida.
15. Thomas, C.V., M.A. DeLorenzo, and D.R. Bray. 1993. Prediction of individual cow milking time for milking parlor simulation models. J. Dairy Sci. 76(8):2184-2194.
16. Thomas, C.V., M.A. DeLorenzo, and D.R. Bray. 1993. Capital budgeting for a new dairy facility. Circ. No. 1110. Gainesville, Fla.: Inst. of Food & Agric. Sci., University of Florida.
17. Thomas, C.V., Armstrong, D.V., Smith, J.F., Gamroth, M.J., and D.R. Bray. 1995. Managing the Milking Parlor for Profitability. 2nd Western Large Herd Dairy Management Conference, Las Vegas, NV, pp. 139-146.
18. Thomas, C.V., M.A. DeLorenzo, R.N. Weldon, and D.R. Bray. 1994. A stochastic economic analysis of large herringbone and parallel milking parlors. J. Dairy Sci. 726(Supp. 1): 129 (Abstr).
19. Welchert, W.T., PE, Armstrong, D.V., J.G. Martin, III, PE. 1994. Dairy Design Consulting Practice. Proc. Of the 3rd Int'l. Dairy Housing Conf., 531-538. Orlando, Fla.: ASAE.

Notes

Notes