

Dairy Facilities-Putting the Pieces Together

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Introduction

Dairy facilities can have a dramatic impact on the performance and health of dairy cows. Over the years field observations and results from research trials have been used to improve dairy facilities. In the United States producers try to minimize facility cost while trying to maximize milk production per cow, reproductive efficiency, and cow health. Producers often use employees to operate their milking parlors as many hours as possible reducing their fixed cost per cow. Under these conditions producers have to be extremely careful where they invest dollars into dairy facilities. These proceedings will discuss some of the issues faced by dairy producers.

Milking Parlors, Holding Pens and Exit Lanes

Reducing stress on cows in the milking facility is very important. These facilities should be constructed to minimize the time cows are away from feed and water. Ideally lactating dairy cows would be in the housing area a minimum of 20 hours per day. Currently, parallel, and rotary parlors are the two predominant types of parlors constructed. 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.

Typically, milking parlors are sized so that cows can be milked once in 10 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. Sizing groups of cows to be milked in these time frames will minimize the time cows are away from feed and water.

The holding pen is the most challenging environment that a dairy cow faces. Holding pen cooling should be used to minimize heat stress in this area. Holding pens are designed based on 1.39-1.49 m² (15-16 ft²) per cow with a group size not greater than 200 cows. If the group size is

greater than 200 cows the area per cow should be increased to 1.49-1.58 m² (16-17 ft²) per cow. Ideally the holding pen should be sized to hold 1.25 groups of cows. Over sizing 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).

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 ft is acceptable. For parlors containing more than 15 stalls per side, a clear exit lane width of 5 to 6 ft. is desired (Smith et al., 1997).

The width of cow traffic lanes should be sized according to group size. When group size is less than 150 cows, 14 ft. traffic lanes are typically used. Lane width is increased to 16 ft. for group sizes from 150 to 250 cows, 20 ft. for group sizes from 251 to 400 and to 24 ft. when group size is greater than 400 cows (Armstrong 2001).

Selecting Cow Housing

The predominant types of cow housing in the Western United States are dry-lots and freestalls. This decision is based on climate, management style, and equity available for constructing dairy facilities. In the Midwest United States 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. The disadvantage of freestall housing is the cost of constructing freestall housing and the costs associated with maintaining the beds and manure management.

One of the critical decisions that producers make is the type of freestall barn they build. The most common types are 4-row or 6-row barns and many times the cost per stall is used to determine which barn should be built. Data found in Table 1 represents the typical dimensions of the barns and Table 2 demonstrates the effects of overcrowding upon per cow space for feed and water. Grant (1998) suggested that feed bunk space of less than 20 cm/cow (8 in/cow) reduced intake and bunk space of 20-51 cm/cow (8-20 in/cow) resulted in mixed results. Even at a 100% stocking rate, the 6-row barn only offers 46 cm/cow (18 in/cow) feed line space. When over crowding occurs this is significantly reduced. Four-row barns, even when stocked at 140% of the stalls, still provide more than 46 cm/cow (18 in/cow) of bunk space. In addition, when water is only provided at the crossovers, water space per cow is reduced by 40% in the 6-row barn as compared to 4-row barns. Research reported by Smith et al., 2001 would indicate that summer respiration rates are higher in 6-row vs. 4-row freestall barns. Many times headlocks are used the primary method used to restrain cows for breeding, estrus synchronization, vaccinations and other common procedures. If headlocks are to be used efficiently there needs to be adequate bunk space to lock up all the cows at the same time. Feedline space recommendations for different groups of cows are presented in Table 3.

Recommendations concerning access to water vary greatly. Current recommendations suggest a range of 3 – 9 linear cm (1.2 to 3.6 linear in) per cow (Smith et al., 2000). In the Midwest, the typical rule is one waterer or 61 cm (2 linear ft) of space for every 10 to 20 cows. In the Southwest, the recommendation is 9 linear cm (3.6 linear in) of space for every cow in the pen. Typically, water is provided at each crossover in 4- and 6-row freestall barns and generally a 4- and 6-row freestall have the same number of crossovers. Thus, water access in a 6-row barn is reduced by 37.5% as compared to a 4-row barn (Table 1). When overcrowding is considered (Table 2) water access is greatly reduced and the magnitude of reduction is greater in 6-row barns. Milk is 87% water and water intake is critical for peak dry matter intake. When building 6-row barns or overcrowding either 4-row or 6-row barns it is important to consider the amount of water space available. In warmer climates, (9 linear cm) 3.6 linear in. of waterer space per cow should be provided.

If construction costs are going to drive the decision between 4- or 6-row freestall barns, overcrowding must be considered. Typically, 4-row barns are overcrowded 10 to 15% on the basis of the number of freestalls in the pen. Due to the limitations of bunk space, many times the 6-row barn is stocked at 100% of the number of freestalls. Thus, comparing the two buildings on a cost per cow basis, rather than a per stall basis would be more accurate. This will make the 4-row more cost comparable to the 6-row and maintain greater access to feed and water.

Table 1. Average pen dimensions, stalls, cows and allotted space per animal.

Barn Style	Pen Width		Pen Length		Stall Per Pen	Cows Per Pen	----- Per Cow -----					
							Area		Feedline Space		Water Space	
	m	ft	m	ft			m ²	ft ²	cm	inch	cm	inch
4-Row	11.9	39	73.2	240	100	100	8.7	94	73.7	29	9.1	3.6
6-Row	14.3	47	73.2	240	160	160	6.6	71	45.7	18	5.7	2.25
2-Row	11.9	39	73.2	240	100	100	8.7	94	73.7	29	9.1	3.6
3-Row	14.3	47	73.2	240	160	160	6.6	71	45.7	18	2.25	2.25

Adapted from Smith, J.F. et al., 1999.

Table 2. Effect of stocking rate on space per cow for area, feed and water in 4 and 6-row barns.

Stocking Rate (%)	Area/Cow				Feedline Space/Cow				Water Space/Cow			
	4-Row		6-Row		4-Row		6-Row		4-Row		6-Row	
	m ²	ft ²	m ²	ft ²	cm	inch	cm	inch	cm	inch	cm	inch
100	8.7	94	6.6	71	73.7	29	45.7	18	9.1	3.6	5.7	2.25
110	7.9	85.5	6.0	64.5	66.0	26	40.6	16	5.8	3.27	5.2	2.05
120	7.3	78.3	5.5	59.2	61.0	24	38.1	15	7.6	3.0	4.8	1.88
130	6.7	72.3	5.1	54.6	55.9	22	35.6	14	7.0	2.77	4.4	1.73
140	6.2	67.1	4.7	50.7	53.3	21	33.3	13	6.5	2.57	4.2	1.66

Table 3. Recommended Groups and Facilities for Cows Housed in the Special Needs Area.

Group	Avg. Time in Facility	% of Lactating Herd	Housing System
Close-up cows	21 days	6%	Freestalls or loose housing
Close-up heifers	21 days	3%	Freestalls or loose housing
Maternity cows	3 days	.33%	Loose housing
Maternity heifers	3 days	.33%	Loose housing
Maternity overflow	3 days	.33%	Loose housing
Fresh cows & heifers, Non-sellable milk	2 days	1%	Freestalls or loose housing
Fresh cows	14 days	3.5%	Freestalls
Fresh heifers	14 days	1.5%	Freestalls
Mastitis & sick cows, non-sellable milk	N/A	2%	Freestalls or loose housing
High risk sellable milk	N/A	2 – 6%	Freestalls or loose housing
Cull and dry cows	N/A	1.5%	Loose housing
Calf housing	24 hours		Hutches or small pens

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 are allotted to one of seven classifications;

1. Healthy lactating heifers
2. Healthy lactating cows
3. Fresh cows and heifers with non-sellable milk
4. Fresh cows with sellable milk
5. Fresh heifers with sellable milk
6. Sick cows with non-sellable milk
7. High risk sellable.

Healthy lactating heifers and cows are typically housed in 8 – 12 groups. The cows in classifications 3-7 are typically housed in the special needs area along with close-up cows and heifers. Table 3 lists suggested pens and pen sizes for different classifications of dairy cattle to be housed in the special needs facility and Table 4 list recommendations for feedline space and stocking density for different groups of cows.

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.

Close-up dry cows and springing heifers differ in nutritional requirements. Close-up cows will 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.

Close-up cows should be moved into a close up pen 21 days prior to calving. The diet in this pen typically has greater concentrations of protein and energy as compared to 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 heifers may benefit from receiving the typical transition diet for 5 weeks rather than 3 weeks. Thus, feeding a diet with higher levels of protein and energy without anionic salts for 5 weeks prior to freshening would be beneficial for heifers.

If close-up cows and heifers are housed in freestalls, they would be moved into a maternity pen at the time of calving. Close-up cows and heifers in loose housing would be allowed to calve in the close-up pen. Following calving cows and heifers are typically co-mingled until the milk can be sold. Cows and heifers would be segregated when they move out of the fresh non-sellable pen into the fresh pens. Cows and heifers would be housed in the fresh pens for 14 days where rectal temperatures, dry matter intakes and general appearance can be monitored on a daily basis. Other pens for mature cows and heifers in the special needs area would be a sick pen which would be used to house cows which had been treated with antibiotics and a high risk pen for lame cows and slow milkers who still produced a lot of sellable milk, however, needed some extra attention.

It is important to realize that these group sizes in the special needs area have been increased to account for fluctuations in calving and cow and heifer numbers. If these pens are sized for static or average numbers there will be a considerable amount of time where the special needs facilities would be over stocked. Over stocking cows prior to or after calving can have a dramatic impact on milk production and cow health.

Table 4. Recommended Feedline Space and Stocking Density for Different Groups of Cows.

Group	Feedline/Cow	Freestalls (Cows/Stalls)
Close-up or Pre Fresh	76.2 cm (30 in)	100%
Fresh Cows	76.2 cm (30 in)	100%
Mid to low Lactation	61-76.2 cm (24-30 in)	100%-110%
For off Dry	61-73.2 cm (24-30 in)	110%-110%

Freestall Surfaces

Deep bedded sand is the freestall surface of choice in many areas. It provides a comfortable cushion that forms to the body of the animal. In addition, its very low organic matter content reduces mastitis risk. Sand is readily available and economical in many cases. Disadvantages may include the cost of sand and/or the issues with handling sand laden manure and separating the waste stream. In arid climates, manure solids are composted and utilized for bedding. Producers choosing not to deal with sand or composted manure bedding, often choose from a variety of commercial freestall surface materials. Cows need a stall surface that conforms to the contours of the cow. Sand and materials that compress will likely provide greater comfort as demonstrated by cow preference.

Feed Barrier Design

The use of self-locking stanchions as a feed barrier is currently a debated subject in the dairy industry. Shipka and Arave (1995) reported that cows restrained in self-locking stanchions for a four-hour period had similar milk production and dry matter intake as those not restrained. Arave et al. (1996a) observed similar results in another study, however a second study showed similar intake but 6.4 lb/cow/d decrease in milk production when cows were restrained daily for a four hour period (9 AM to 1 PM) during the summer. Increases in cortisol levels were also noted during the summer but not in the spring (Arave et al., 1996b) indicating increased stress during the summer as compared to the spring. Another report (Bolinger et al., 1997) found that locking cattle for 4 hours during the spring months did not affect milk production or feed intake. All of these studies compared restraining cows for four hours to no restraint and all animals were housed in pens equipped with headlocks. The studies did not compare a neck rail barrier to self-locking stanchions nor address the effects of training upon headlock acceptance. The argument could be made that four hours of continuous restraint time is excessive and much shorter times (one hour or less) should be adequate for most procedures. These studies clearly indicate that mismanagement of the self-locking stanchions, not the stanchions resulted in decreased milk production in one of three studies with no affect upon intake in all studies.

Another study (Batchelder, 2000) compared lockups to neck rails in a 4-row barn under normal and crowded (130% of stalls) conditions. Results of the short-term study showed a 3-5% decrease in dry matter intake when headlocks were used. No differences in milk production or

body condition score were observed. It was also noted that overcrowding reduced the percentage of cows eating after milking as compared to no overcrowding. In this study, use of headlocks reduced feed intake but did not affect milk production.

A study was conducted by Brouk et al. in the summer of 2000 to determine the effect of headlocks and neckrails on milk production and dry matter intake. This trial was conducted on a commercial dairy and included 216 lactating Holstein cows (55, 2 year olds and 53 mature cows per pen) previously exposed to headlocks. Headlocks did not adversely affect milk production or dry matter intake in this trial. In summary, it does not appear that headlocks adversely affect milk production if they are managed correctly.

The feeding surface should be smooth to prevent damage to the cow's tongue. When eating, the side of the tongue, which is much more easily injured, often contacts the manger surface. The use of plastics, tile, coatings, etc. will provide a smooth durable surface reducing the risk of tongue injury.

Cow Handling Systems

The current cow handling systems are lock-ups, sort gates, palpation rails, chutes, and combinations of the systems listed previously. Sort gates require electronic identification. They work fairly well to sort groups of cows of the parlor to be moved, beefed, dried off, etc. Managing reproduction as cows leave the milking parlor using sort gates is very difficult. Often times cows can not be processed fast enough putting employees and veterinarians in a position where they have to watch the clock. Inevitably, a second holding pen is created increasing the time cows are away from feed and water. This also creates a situation where cows can very easily end up in the wrong pen after they are processed. Headlocks have been used in the western United States for many years. Headlocks are a very efficient way to handle large number of cows, however, they can be mismanaged. Producers should strive to reduce lock-up times to 1 hour per day. Locking cows up in the afternoon during summer months should be avoided. Heifers should be exposed to and trained to use lockups prior to entering the close-up pen.

Managing Heat Stress

Heat stress management is a critical factor that needs to be considered when designing a dairy facility. The factors that need to be considered are discussed in a separate paper in these proceedings.

Facility Bottlenecks to Cow Cooling

Often producers do not plan to cool cows when they are building new dairy facilities. This creates serious problems in cooling cows. The biggest bottleneck is water availability to soak

cows on the feedline in cow housing areas. Another problem is the lack of provisions to provide electricity for fans. It is much more economical to put the electrical system necessary for fans when the structures are built versus retrofitting the wiring at a later date. The majority of the dairies being built today do not have water or electrical systems to meet the demands of cow cooling.

Supplemental Lighting

Supplemental lighting has been shown to increase milk production and feed intake in several studies. Peters (1981) reported a 6% increase in milk production and feed intake when cows were exposed to a 16L:8D photoperiod as compared to natural photoperiods during the fall and winter months. Median light intensities were 462 lx and 555 lx for supplemental and natural photoperiods respectively. Chastain et al. (1997) reported a 5% increase in feed intake when proper ventilation and lighting were provided and Miller et al. (1999) reported a 3.5% increase without bST and 8.9% with bST when photoperiod was increased from 9.5-14 h to 18 h. Increasing the photoperiod to 16-18 h increased feed intake. Dahl et al. (1998) reported that 24 h of supplemental lighting did not result in additional milk production over 16 hours of light. Studies utilized different light intensities in different areas of the housing area. More research is needed to determine the correct light intensity to increase intake. In modern freestall barns, the intensity varies greatly based on the location within the pen. Thus additional research is needed to determine the intensity required for different locations within pens.

Another issue with lighting in freestall barns is milking frequency. Herds milked 3x can not provide 8 hours of continuous darkness. This is especially true in large freestall barns housing several milking groups. In these situations, the lights may remain on at all times to provide lighting for moving cattle to and from the milking parlor. The continuous darkness requirement of lactating cows may be 6 hours (Dahl, 2000). Thus, setting milking schedules to accommodate 6 hours of continuous darkness is recommended. The use of low intensity red lights may be necessary in large barns to allow movement of animals without disruption of the dark period of other groups.

Dry cows benefit from a different photoperiod than lactating cows. Recent research (Dahl, 2000) showed dry cows exposed to short days (8L:16D) produced more ($P < .05$) milk in the next lactation than those exposed to long days (16L:8D). Petitclerc et al. (1998) reported a similar observation. Based on the results of these studies, dry cows should be exposed to short days and then exposed to long days post-calving.

Manure Management

Dairies will generate .9-1.4 kg (2-3 lb) of manure and wastewater per kg (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 2.3-3.1 meters per second (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 22.7 kg (50 lb) of sand per cow per day. Dairies can reclaim sand with gravity or mechanical sand separators. Sand separation generally requires stocking piling reclaimed sand 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 manure on berms or at the edge of fields to provide additional storage requires additional handling and containment structures to control nutrients leaching from the stockpile area.

Putting the Pieces Together

Designing and constructing a dairy facility to maximize cow comfort and labor efficiency is a big challenge. Some of the common mistakes include;

1. Group size does not match up with the parlor size. The result is that cows spend too much time away from feed and water.
2. Freestall barns are orientated north south to save on dirt work putting the cows in the sun.
3. The manure system is not designed to handle sand bedding in the freestalls.
4. Close-up and fresh cow housing is undersized.
5. The cow cooling system does not match up with the environment.
6. The cow handling system creates a situation where cows are away from feed and water too long.
7. Insufficient access to water.

Careful planning will help prevent many of these problems into a new facility. It is extremely important to keep the investment per cow as low as possible, while increasing the production per cow.

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