Cow Facilities and Effects on Performance

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Take Home Messages

- Maximizing access to feed and water is a critical design factor.
- Selecting cow housing is a critical decision. Avoid just looking at initial investment cost of freestall barns.
- Stress should be minimized in the milking facility by limiting the time cows are away from feed and water.
- Avoid building bottlenecks into the dairy design that limit your ability to correctly group cows.
- Design your dairy to manage heat stress in the holding pen and cow housing.

Introduction

Dairy facilities can have a dramatic impact on milk production and cow health. 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. This paper will discuss some of the issues faced by U.S. 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 time cows are away from feed and water. Travel time to and from the parlor can be reduced by correctly sizing travel and parlor exit lanes. Currently, herringbone, parallel, and rotary parlors are the three 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 1.35 m^2 per cow with a minimum capacity of one group of cows. When a wash pen is not used, 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 .92 m is acceptable. For parlors containing more than 15 stalls per side, a clear exit lane width of 1.5 to 1.8 m 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, 4.3 m traffic lanes are typically used. Lane width is increased to 5.5 m for group sizes from 150 to 250 cows, 6.10 m for group sizes from 251 to 400 and to 7.3 m 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 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 50.8 cm annually (Sweeten et al.1993). However, frequency and severity of winter rainfall and blizzards is becoming an important selection criteria. These facilities would provide 45-63 m^2 per lactating cow depending on the evaporation rate and 3.6-4.5 m^2 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. 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 either 4- 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 20.3 cm/cow reduced intake and bunk space of 20.3-50.8 cm/cow resulted in mixed results. Even at a 100% stocking rate, the 6-row barn only offers 45.7 cm/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 45.7 cm/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. Much of the current debate over the effect of 4- and 6-row barns upon intake is likely related to presence or absence of management factors which either reduce on increase the limitations of access to feed and water in 6-row barns.

Recommendations concerning access to water vary greatly. Current recommendations suggest a range of 3.0 to 9.1 linear cm per cow (Smith et al. 2000). In the Midwest, the typical rule is one waterer or 61 linear cm of space for every 10 to 20 cows. In the Southwest, the recommendation is 9.1 linear cm 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, 9.1 linear cm of waterer space per cow should be provided.

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

					------------ Per Cow -----------		
Barn Style	**Pen Width (m)**	**Pen Length (m)**	**Stall Per Pen**	**Cows Per Pen**	**Area (m^2)**	**Feedline Space (linear cm)**	**Water Space (linear cm)**
4-Row	11.9	73.2	100	100	8.5	73.7	9.1
6-Row	14.3	73.2	160	160	6.4	45.7	5.7
2-Row	11.9	73.2	100	100	8.5	73.7	9.1
3-Row	14.3	73.2	160	160	6.4	45.7	5.7

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 (m^2/cow)**		**Feedline Space (linear cm/cow)**		**Water Space (linear cm/cow)**	
	4-Row	**6-Row**	**4-Row**	**6-Row**	**4-Row**	**6-Row**
100	8.5	6.4	73.7	45.7	9.1	5.7
110	7.7	5.8	66.0	40.6	8.3	5.2
120	7.0	5.3	61.0	38.1	7.6	4.8
130	6.5	4.9	55.9	35.6	7.0	4.4
140	6.0	4.6	53.3	33.0	6.52	4.1

If construction costs are going to drive the decision between a 4- or 6-row freestall barn, 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 based on a per cow housed 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.

▪ 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-saleable milk
4. Fresh cows with saleable milk
5. Fresh heifers with saleable milk
6. Sick cows with non- saleable milk
7. High risk saleable.

Healthy lactating heifers and cows are typically housed in 8 – 10 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.

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

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.

Just prior to calving close-up cows and heifers would be moved into a group pen (Maternity) with a bedded pack where they would calve. 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 saleable milk however need 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 calvings 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 facility would over stocked. Over stocking cows prior to or after calving can have a dramatic impact on milk production and cow health.

■ Freestall Surfaces

Sand is the bedding 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. Sonck, et al. (1999) observed that when given a choice, cows prefer some materials. Occupancy percent ranged from over 50 to under 20%. Researchers suggested that the increase in occupancy rate was likely influenced by the compressibility of the covering. Cows selected freestall covers that compressed to a greater degree over those with minimal compressibility. 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) 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 correct feed barrier slope is also important. Hansen and Pallesen (1994) reported that sloping the feed barrier 20° away from the cow increased feed availability because the cows could reach 14 cm further than when the barrier was not sloped. Pushing feed up more frequently could achieve the same affect. One disadvantage of sloping the feed barrier is that feeding equipment is more likely to come in contact with the barrier which may result in significant damage to both.

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.

▪ Enhancing Production Potential Environmental Temperature

Mature dairy cattle generally have a thermal neutral zone of 5 to 20°C. This may vary somewhat for individual cows and conditions. Within this range, it is generally assumed that impacts upon intake are minimal. However, temperatures below or above this range alter intakes.

▪ Effects of Heat Stress

Heat stress reduces intake, milk production, health and reproduction of dairy cows. Spain et al. (1998) showed that lactating cows under heat stress decreased intake 6-16% as compared to thermal neutral conditions. Holter et al. (1996) reported heat stress depressed intake of cows more than heifers. Other studies have reported similar results. In addition to a reduction in feed intake, there is also a 30 to 50% reduction in the efficiency of energy utilization for milk production (McDowell et al. 1969). The cow environment can be modified to reduce the effects of heat stress by providing for adequate ventilation and effective cow cooling measures.

▪ Ventilation

Maintaining adequate air quality can be easily accomplished by taking advantage of natural ventilation techniques. Armstrong et al. (1999) reported that a 4/12 pitch roof with an open ridge resulted in lower afternoon cow respiration rate increases as compared to reduced roof pitch or covering the ridge. They also observed that eave heights of 4.3 m resulted in lower increases in cow respiration rates as compared to shorter eave heights. Designing freestall barns that allow for maximum natural airflow during the summer will reduce the effects of heat stress. Open sidewalls, open roof ridges, correct sidewall heights and the absence of buildings or natural features that reduce airflow increase natural airflow. During the winter months, it is necessary to allow adequate ventilation to maintain air quality while providing adequate protection from cold stress.

Another ventilation consideration is the width of the barn. Six-row barns are typically wider that 4-row barns. This additional width reduces natural ventilation. Chastain (2000) indicated that summer ventilation rates were reduced 37% in 6-row barns as compared to 4-row barns. In hot and humid climates, barn choice may increase heat stress resulting in lower feed intake and milk production.

▪ Cow Cooling

During periods of heat stress, it is necessary to reduce cow stress by increasing airflow and installing sprinkler or soaker systems. The critical areas to cool are the milking parlor, holding pen and housing areas. First, these areas should provide adequate shade. Barns built with a north-south orientation allow morning and afternoon sun to enter the stalls and feeding areas and may not adequately protect the cows. Second, as temperatures increase, cows depend upon evaporative cooling to maintain core temperature. The use of sprinkler/soaker and fan systems to effectively wet and dry the cows will increase heat loss from the cow. It is important to realize that the systems do not lower the temperature in the barn.

▪ Cold Stress

Dairy cows can withstand a significant amount of cold stress as compared to other animals. Factors affecting the ability of the cow to withstand cold temperatures include housing, pen condition, age, stage of lactation, nutrition, thermal acclimation, hair coat and behavior (Armstrong and Hillman, 1998). Feed intake increases when ambient temperature drops below the lower critical temperature of the animal. Protection from wind and moisture will reduce the lower critical temperature and minimize the effects of cold stress. When feed intake is no longer adequate to maintain both body temperature and milk production, milk production will likely decrease.

▪ 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.

▪ Lot Condition

Mud can have a significant negative impact upon dry matter intake. Fox and Tylutki (1998) suggested that every inch of mud reduced DMI of dairy cattle 2.5%. Based on this assumption, feed intake of cattle in 30.5 cm of mud would be 30% less than those without mud. Based on our current knowledge of the impact of prepartum intake upon subsequent lactation performance, dry cattle housed in muddy conditions may be at greatest risk. However, significant production losses may also occur in lactating cattle.

▪ Impact of Facilities on Reproduction

A dairy design that facilitates grouping open cows together is ideal allowing nonpregnant cows to interact during estrus, increasing the efficiency of heat detection (Helmer and Britt, 1985). In a trial conducted by Vailes and Britt in 1990 cows given a choice spent 73% of the time on dirt versus concrete and mounting activity was 3-15 fold greater on dirt versus concrete. Duration of estrus and mounting activity is increased when cows are housed on dirt versus concrete (Britt et al., 1986; Rodtain et al., 1986). If possible producers may want to allow open cows to have access to dirt lots for the purpose of estrus detection.

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