Nutritional Interactions Related to Dairy Shelter Design & Management

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Take Home Message

- The design and management of each animal shelter component (feeding, resting, drinking, floor surface, ventilation) can influence the willingness and ability for dairy cows to consume an adequate amount of dry matter.
- The design of the feeding area should provide a comfortable feeding experience for cows and convenient management for the caretaker.
- Good animal shelter and feeding area design can not make up for poor (or varying) feed quality or poor management.
- Even an engineer can feed a hungry cow!

Animal Shelter Design Basics

Clean, healthy, productive dairy cows require at least five basic things from a dairy shelter. They include:

- Excellent air quality
- A clean, dry, comfortable resting area
- Convenient access to (and supply of) good quality feed
- Convenient access to (and supply of) good quality water
- Confident footing

These elements provide the opportunity for the cows to be productive and must not be compromised in dairy shelter design.

Proper design and management of a dairy shelter – not just the feeding area – is necessary in order for dairy cows to take full advantage of a ration that has been carefully balanced, formulated, prepared and delivered.

This paper will briefly describe some design considerations for the feeding and drinking water areas, as well as some other factors that may influence feed intake and animal health in freestall shelters.

■ Factors Influencing Feed Intake

While good design of the feeding and drinking water areas is important. It's not the only thing that may prevent or discourage dairy cows from consuming a desired (or expected) amount of dry matter. The following factors contribute to reduced feed intake:

1. Feed not available to cows
2. Cows not available to feed
3. Poor and/or varying feed quality
4. Undesirable eating area
5. Feed not within reach
6. Sick cows
7. Injured cows
8. Lame cows
9. Hot cows
10. Thirsty cows
11. Submissive cows
12. Feeding area hard to get to
13. Cows associate pain with feeding
14. Not enough feeding space

For items 1 – 5 feeding area management has more influence than design. These items may seem obvious or trivial, but are often overlooked. How many farms have you visited where the feed table was empty or feed not pushed within cow reach? Timely feed delivery, feed "push back", and feed area cleaning are typically high priority tasks on dairy farms achieving high levels of milk production. The amount of time cows spend away from feed (milking center, exercise lot, etc.) should also be considered. Many producers, dairy scientists, and nutritionists suggest that cows should not be away from feed more than 3 hours per day. The more time cows spend away from the feeding area, the more critical adequate feeding space becomes since they may all have to eat at the same time.

Healthy, mobile cows are more likely to visit the feeding area regularly. The environment surrounding the cows and herd health management influence items 6 - 9. Air quality, resting area comfort and cleanliness, and the surface they walk all affect cows' health and well-being. Ventilation system design and management should provide an adequate air exchange and good air mixing during all seasons. The resting area should provide comfort, promote cleanliness, and reduce the chance of injury. The floor surface should be cleaned regularly (especially in cold weather), provide good traction, and not injure the cows' feet. Space should be provided to isolate sick, injured and/or lame cows that need to be separated from the rest of the group and they should receive special care for recovery.

Heat stress can significantly affect feed intake. If a cow cannot adequately get rid of the heat she is producing, why create more? Good ventilation and heat stress abatement methods (circulation fans, spray cooling, and/or evaporative cooling) can help cows maintain dry matter intake and milk production during hot weather.

■ The Feeding Area – Group Housing

The remaining items on this list influence the design of the feeding area. Proper design of the feeding area considers cow dimensions, typical bovine feeding behavior, the method of feed delivery, and management of the feeding area. The feeding area should (Graves, 1998, McFarland, 1994):

- Encourage and allow each cow to consume an adequate amount of feed dry matter during each feeding episode and throughout the day.
- Provide a comfortable feeding experience for the cow.
- Facilitate 24-hour availability of high quality feed.
- Be clean and easy to clean.

Basic guidelines for the design, construction, and management of modern group feeding systems include (Graves 1998):

- Cows are fed at a fenceline, not a walk around feed bunk.
- Facing fencelines are far enough apart to negate feeling of confrontation.
- Cow alleys wide enough to allow cows and caretakers to pass behind "feeding" cows without disturbing them
  - minimum 12' clear allows two cows to pass behind "feeding" cows
  - 13' – 14' clear if rear of freestalls located adjacent along opposite edge of feeding alley
- Cows eat in normal head down (grazing) position.
  - eating surface (feed table) 2" – 6" above cow alley
- Flat feed table to encourage easy mechanical clean out and feed push up.
- Smooth, non-porous, easy to clean eating surface (feed table).
  - 32" – 36" wide
- A hard surface area at same elevation as eating surface where feed is "stored" after delivery or where cows may "push" feed back during eating.
  - approximately 2' wide
  - surface beyond feed table should slope away 1/8" per ft.

    - Feed should be pushed or scraped back to the eating surface, towards the cow without becoming contaminated with gravel or mud from unpaved driveway or vehicle track in.

- Driveway is wide enough to allow delivery vehicle to pass without driving where feed is to be delivered, or on previously delivered feed.
    - feed delivery alleys with feeding fenceline on both sides
        - minimum 16' clear
        - 8' – 20' preferred
    - feed delivery alleys with feeding fenceline on one side.
        - minimum 12' clear
        - 13' - 14' clear preferred

- Door openings should be wide and high enough to allow largest expected feeding equipment to pass without damage
    - 14' high typical
    - door width should be at least 1'-2' wider than feeding unit with discharge chute in feeding position.

- Separation device, or feed barrier, allows cows' convenient access to feed table without undue twisting, turning, or repositioning of the head and neck.

- Expected contact points between cow and separation device are shaped and located to prevent abrasion, penetration or bruising.

Feeding space per cow is calculated by dividing the total length of feeding space provided along the fenceline by the number of cows that have access to it. Approximately 27"-30" of feeding space per cow is needed for the entire group to stand and eat comfortably at the fenceline at the same time. Well-designed two-row and four-row freestall shelters can provide enough fenceline length for all cows in a group to eat at once, if the group is not overpopulated.

Properly designed three-row and six-row freestall shelters provide approximately 19" of feeding space per cow, which is not enough for all cows in the group to eat at once. Overpopulating a group further reduces the available feeding space per cow. Table 1 shows the affect of various overpopulation rates on available feeding space per cow. Whether it is important for all cows to eat at the same time is a management decision, not an engineering decision (Graves 1998). One study of two six-row freestall shelters by Menzi and Chase (1994) indicated that even with limited feed space (15" – 16" per cow), the feeding area was fully occupied infrequently. No loss in production could be attributed to limited feeding space. However, they also recognized the limited nature of the study and need for further research.

Table 1. Affect of various group population rates on approximate feeding space per cow in typical freestall shelters

Overpopulation rate	Approximate feeding space per cow	
0%	30"	19"
10%	28"	17.6"
20%	26"	16.2"
30%	24"	14.9"
40%	22"	13.9"
50%	20.5"	13.0"

A study of feed bunk length requirements for Holstein dairy heifers found that limited feed bunk length did not affect group growth rates, but significantly affected individual growth rates (Longenbach et al., 1999). Perhaps the same is true, with respect to individual dry matter intake and milk production of lactating dairy cows. Again, further research on feeding space for high producing dairy cows is necessary.

To allow better access and more uniform feed consumption along the length of the feeding area a crossover lane to the feeding area should be provided every 60' – 80' (McFarland 1994). This is especially important in freestall arrangements where access to 67% - 100% of the stalls is located in the alley opposite the feeding alley.

The feed barrier must allow the cow convenient, injury free, access for eating while preventing her from walking onto the feeding area. She should be allowed to access the feed in a natural way with a minimum of annoyance or obstruction from the feed barrier, or separation device. The separation device should also protect the feed from contamination by manure and minimize feed spillage into the standing area (Graves 1998). Two feed barriers commonly found in modern freestall shelters are the post and rail design, and self-locking stanchions (Figure 1).

The post and rail feed barrier provides excellent access to the feed table for cows, and is relatively inexpensive to construct. Proper placement of the upper rail allows the cow good access to feed with a minimum of interference. The neck of the cow should only nudge the rail slightly when she is reaching for feed.

Self-locking stanchions, or "head-locks", allow the manager to restrain a group of cows, or a single cow, for observation, treatment, or other herd management

activities. They are often mounted on a slant so that the cows can reach further into the feeding area more comfortably (Dumelow and Sharples 1988).

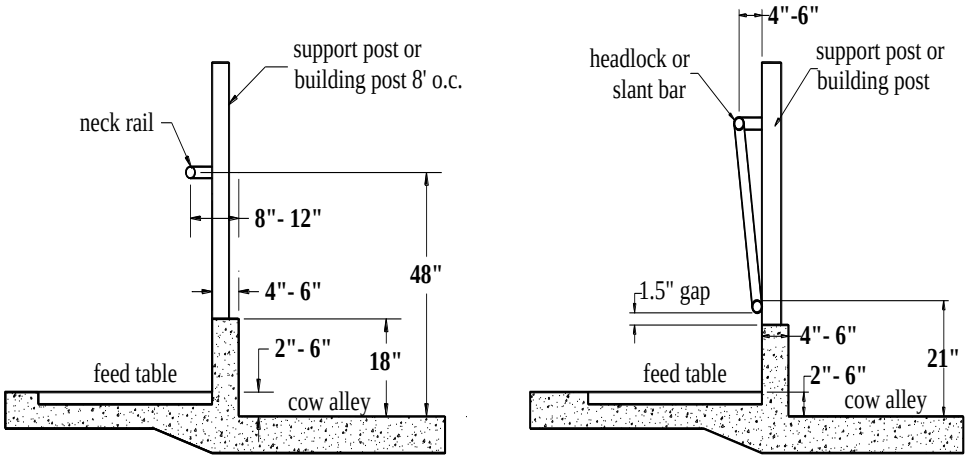

Figure 1. Typical feed barrier types and dimensions for mature Holstein cows (1,400 lb).

It is important to select a stanchion design that allows each cow to insert her head and neck easily and comfortably through the access opening without excessive twisting and turning. Some manufacturers have overlooked this important design consideration, perhaps intending to provide more opening in a given space, simplifying assembly, or saving material. Downed cows are also a concern with this feed barrier type. Fortunately, designs are available that allow the lower section to open wide to aid in cow release.

The eating surface must be smooth, clean, and free of left over feed and debris in order to encourage good feed intake and aid in the control of disease (Bickert 1990). The low pH of silage can etch the manger surface, exposing the cow's tongue and mouth to rough edges (Albright 1983). High strength concrete and admixtures are used to improve the durability of feeding surfaces. Properly installing tile along the length of feed table provides a durable, smooth surface. Epoxy coatings are also used, but must be applied properly to allow good adhesion (McFarland 1994).

Without proper care and management any feeding system design can fail. Feed should be readily available to the cows, as well cows available to feed. This is especially important in feeding areas with limited feeding space and/or

overpopulated groups. Cows tend to work feed away from the feed table and out of reach when eating. Feed should be pushed up regularly so that it is available to other cows in the group. The feed table should be scraped clean of feed and debris daily, so fresh feed can be put in its place. In addition, the feeding area should be well ventilated and the cow alley cleaned frequently so cows do not have to stand in an accumulation of manure and urine.

■ Good Access to Water

Water plays an important role in milk production, temperature control, and body functions for dairy cattle. Cows may consume 4.5 to 5 pounds of water, from drinking and feed, per pound of milk produced (NDPC-30 1990). Providing the opportunity for dairy cows to consume a relatively large quantity of clean, fresh water is essential.

Drinking water satisfies 80%- 90% (Table 2) of the dairy cow's total water needs (Ishler 1998). Therefore, it is logical to assume that plenty of good quality drinking water be conveniently located in areas where cows spend most of their time, and offered from watering units that allow the cows to drink water easily. Mature cows can consume up to 5 gallons of water per minute. The water system must be designed to deliver water to each station at the proper rate and keep up with peak demand. Each water station should also be easy to clean and cleaned regularly.

Cows seem to have the highest water intake during hours when feed intake is greatest. When given the opportunity, cows tend to alternately consume feed and drink water. Fresh, clean water should be available whenever cows consume feed (Grant, 1993). Cows also seem to quite willing to drink water soon after being milked. Many areas of the United States experience extended periods of hot weather where cows experience heat stress. Therefore, having plenty of drinking water available, and even supplementing it during warm weather is very desirable.

Table 2. Drinking water intake by dairy cattle (adapted from Adams, R.S., et al.1995).

	Daily Milk Production (lbs/day)	Daily Drinking Water Intake[1] (gallons/day)
Lactating cows[2]	30	18 - 22
	50	23 - 27
	80	30 - 36
	100	35 - 41
Dry cows	Pregnant (6 – 9 mo)	7 - 13

[1] Higher water intakes apply to higher dry matter rations
[2] Cattle under heat stress may require 1 – 1.2 times more water per day (Beede 1991)

Basic Water Station Design Guidelines:

- Provide at least two water stations per group (Graves 1995).
  - reduces affect of dominant cows
- Provide adequate water vessel space.
  - allow 15 – 20% of the group to drink at the same time (Armstrong 1998).
    - 3.5" – 4.8" accessible trough perimeter per cow
  - allow minimum of 5% - 7% of group to drink at the same time (Bickert et al. 1997).
    - 1.2" – 1.6" accessible trough perimeter per cow
- Place water stations in cross overs (Figure 2).
  - minimum 11' clear for single file travel behind "drinking" cows
  - minimum 15' clear for two direction travel behind "drinking" cows
- Place water vessel at proper height (Figure 3).
  - top edge 24" – 32" from cow alley for large framed cows
    - reduce 2" – 3" for smaller framed cows
  - water level 2" – 4" below top edge
  - shallow water depths (4" – 8") preferred
- Place guard rail 48" – 60" directly above waterer top edge
  - Provide 24" clear vertical opening
- Provide concrete support base that provides a 2" ledge around perimeter of waterer.

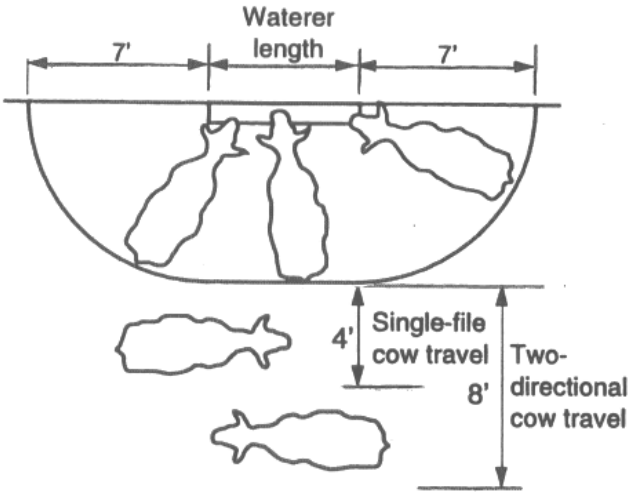

Figure 2. Space required for mature cows around water stations (Graves et al. 1997).

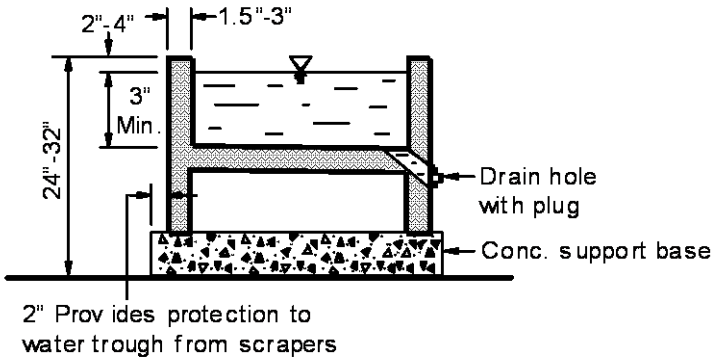

Figure 3. Cross section of concrete or polyethylene water trough (Graves, et al., 1997).

■ The Resting Area

Dairy cows spend a significant portion of the day ruminating. It seems that a recumbent position is the best, most efficient posture for this process. When cows lie down they also take pressure of their feet and legs which can reduce stress and reduce lameness. A number of studies indicate that cows tend to lie

down 10 to 12 hours per day. The type of housing, comfort of the stall or resting area, type of diet, pregnancy, and climatic factors all have an affect on the lying time of lactating dairy cows (Albright and Arave 1997).

Properly designed freestalls provide a clean, dry, comfortable resting area with good air circulation, protection from other animals, and do not cause injury or trap a cow. Ease of maintenance is also important, but animal comfort and cleanliness should be the primary factors to consider when selecting a freestall combination.

The dimensions and structure of freestalls should allow each cow to enter stall, recline easily, rest comfortably, rise easily, and exit the stall. As cows rise they lunge forward shifting their weight ahead allowing them to raise their hind quarters more easily. The designer and builder should get accurate information concerning cow size and grouping of the milking herd. Figure 4 shows typical freestall dimensions for mature Holstein cows (1,400 lb.) using mattress and generously bedded stall beds. Stall dimensions should accommodate the largest cows in the group.

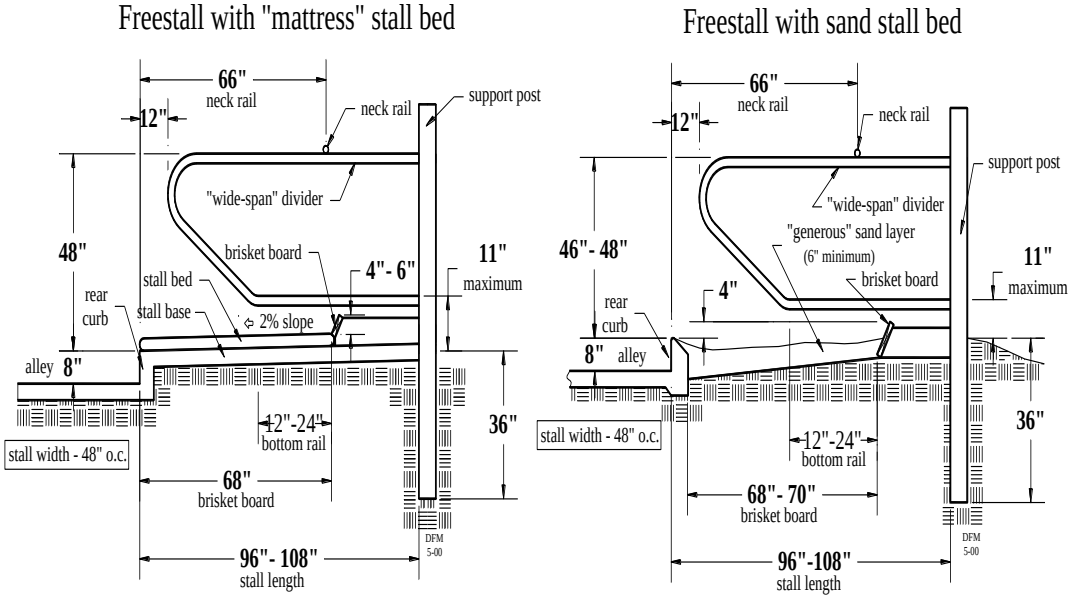

Figure 4: Typical Freestall Dimensions for Mature Holstein Cows (1,400 lb.)

The resting surface should be resilient so it can conform to the shape of resting cows, provide cushion when rising and reclining and traction so they can enter and exit the resting area easily. There are many satisfactory stall bed alternatives to consider. Generous amounts of inorganic (sand, limestone

tailings, etc) and organic (sawdust, straw, shavings, etc.) bedding can provide a suitable surface. Another alternative, often referred to as “mattresses”, typically use a fabric cover to secure a layer of resilient material such as crumb rubber, molded rubber, or foam. Yet another alternative uses a bladder filled with water as the resting surface for each stall.

While resting, the udder and teats contact the resting surface. Therefore, the resting surface must be clean and dry. This requires not only good stall design but diligent stall management which includes frequent stall surface grooming and regular bedding intervals. Manure and wet spots should be removed from the stalls at least 3 times per day.

Bedding amount, application and management should be determined by the cows not the calendar. The bedding application interval will vary with the material used and the season. Generously bedded sand stalls should be bedded 1 – 2 times per week and typically use 25 - 50 lbs per stall per day, even with “sand saving” devices installed. Organic bedding is usually applied over mattress stall beds. Since it is difficult to keep bedding on the fabric cover, fresh bedding should be added every 1 - 2 days. When the weather is cold and wet, more bedding and more frequent application may be necessary to keep the desired level of cow cleanliness and comfort.

■ Good Ventilation

The importance of good air quality cannot be understated. Fresh, dry air is essential to the health and well-being of cows and caretakers. Good ventilation provides the necessary air exchange to remove excess moisture, gases, pollutants and heat produced by the animals, manure, bedding material, and feed stuffs. Moisture control is the primary concern. A significant amount of moisture is added to the air as cows breathe (3 - 7 gal/cow-day) and evaporation from the alleys and it must be removed from the building.

Natural ventilation is usually the most practical system for freestall shelters. The primary goal of a natural ventilation system is to provide similar air quality inside the building as outside with respect to moisture level, gas concentrations, and pollutants. During cold weather temperature is not the primary concern. As long as the cows are protected from cold winds, kept dry, and fed properly they will remain healthy and productive. During hot weather the removal of excess heat from the building and air movement over the cows, using circulation fans at the feeding and resting areas, helps reduce heat stress. Further heat stress abatement can be achieved by adding spray cooling along the feeding area or high pressure misting in the entire animal area.

Basic natural ventilation design guidelines:

- Proper building orientation is important.
  - position building length 45o – 90o to predominant prevailing winds.
    - allows ridge opening to "draw" air more uniformly
    - breezes blow across the width of the building
  - east-west orientation favors summer shading patterns
    - minimal sunlight intrusion into animal area
- Provide adequate separation.
  - 50' minimum from obstructions that block air flow
    - buildings, trees, silos, etc.
  - 75' preferred to allow fire fighting equipment to maneuver
    - "wind shadow" created by long and/or tall obstructions may increase necessary distance
- Sidewall height 12' – 16'.
  - adds building volume
  - moves roof further away from animal level (reduces heat stress)
  - allows opportunity for more air to enter and exit building
- Adjustable sidewall and end wall openings.
  - minimum sidewall opening ½ ridge opening (each side)
  - open side and end walls as much as possible in warm weather
    - especially at cow level
  - block cold winds and precipitation as needed
  - automatic control of sidewall openings preferred
    - with proper adjustment and management
- Ridge opening
  - 2" – 3" continuous ridge width opening per 10' of building width.

■ Confident Footing

All surfaces that cows come in contact with should provide a confident, non-skid footing. A floor surface that provides confident footing reduces the chance of serious injury caused by slipping and falling. Also, cows are more likely to mount and show signs estrus in a area with a good, non-skid footing.

Basic Cattle Flooring Construction Guidelines:

- Use 3,500 psi air entrained concrete
- Well-drained compacted subgrade.
- Floor thickness 4" – 5" depending on vehicle traffic.

- Groove size
  - 3/8" – ½" wide
  - 3/8" – ½" deep
- Groove pattern
  - parallel: 2" – 4" o.c. in direction of scraper travel
  - diamond: 4" – 6" o.c. each direction
- Form grooves before curing or saw in later.
  - sawn grooves create "cleaner" edge
- Remove sharp edges and exposed aggregate before allowing cows access.
  - wash and/or sweep debris away

In recent years resilient flooring (rubber belting, rubber mats, EVA mats, etc.) have become popular in dairy freestall shelters, especially along the feeding area and in the holding area. Limited information is available as to the short and long term benefits of these materials. Observation indicates that cows prefer a resilient floor surface to concrete. However, some resilient flooring materials become slippery when wet, while durability has been a problem with others.

Summary

Feed, water, and air are essential elements in the production of quality milk. The design and management of each component of a dairy shelter, which includes the feeding and drinking water areas, the resting area, floor surfaces, and ventilation system, influences the cow's willingness and ability to consume an adequate amount of dry matter. Dairy system designers need to pay close attention to the needs of cows and all aspects of the animal area when developing designs and recommendations. Dairy cows should be able to consume large volumes of fresh, good quality feed and water, easily, comfortably, and without injury. The design of the feeding and watering areas should also allow the caretaker to perform the tasks of feed delivery, observation, maintenance, and cleaning easily and safely. Access to feed and water should not limit the production and profit potential of a modern dairy enterprise.

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