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A Flowchart for Evaluating Dairy Cow Freestalls

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Abstract

A flowchart system has been developed to evaluate dairy freestalls. It details four critical points: adequate surface cushion; adequate body resting space; lunge room for head thrust and an unobstructed "bob-zone"; and adequate height below and behind the neck rail. Surface cushion is considered to be the most important factor in determining stall usage. If the stall allows a full forward lunge, the configuration of the stall divider has little importance. If side lunge is required, the exact height of the divider rails is critical. Several clinical problems that result from inadequate stalls are discussed.

Résumé

Un organigramme a été développé pour évaluer les étables laitières à stabulation libre. L'organigramme comprend quatre éléments critiques : des revêtements de surface adéquats, une aire de repos adéquate, un espace avant permettant l'avancement de la tête et une zone sans entrave pour le mouvement de rase-mottes enfin un bon réglage de la hauteur de la barre de cou. Le revêtement de surface est considéré comme le facteur le plus important dans l'utilisation des logettes. Si la logette permet à la vache de prendre un élan vers l'avant, le type de séparateur de la logette n'est pas important. Si un élan latéral est requis, la hauteur de la partie inférieure du séparateur devient alors critique. Plusieurs problèmes cliniques qui découlent de l'emploi de logettes inadéquates sont discutés.

Introduction

Deficits in freestall design and maintenance have long been recognized as significant risk factors for mastitis, hock abrasions and hygromas, teat trauma and entrapment injuries of dairy cows.[2,14,20] Uncomfortable stalls result in less frequent or shorter duration resting periods and by default, increased standing time on concrete surfaces. There is increasing evidence for an association between standing time on concrete and the induction of laminitis.[5,6,11,12] If the stalls are uncomfortable, the cow may choose to lie down in a slurry-covered alleyway and put herself at risk for environmental mastitis infection. A poor stall can put a cow in a situation where she is "damned if she uses it and damned if she doesn't".

There are several reasons that problems are commonly found with freestalls. First, it is only within the last 10-15 years that freestall design has moved beyond static measurements of body size and focused upon the space required to lie down and rise. Recommended stall designs as recently as 1985 show engineers' drawings of stalls which were considered woefully inadequate a decade later, and many of these stalls remain in use today.[3] Second, evolution of stall design has led to a variety of types, some which require cows to lunge into the adjacent stall space and others that require the cow to lunge directly forward. Because builders may not understand the functional assumptions of the stall type that they are building, inappropriate dimensions copied from a different stall design sometimes create disastrous installations. Third, from the standpoint of the cow, the location of the divider rails is relative to the stall surface. Sometimes the location of the stall surface changes, either through the addition of a mattress or conversely because of the removal of loose bedding. This changes the distance between the stall surface and the divider rails, potentially converting a good divider design into a disaster. Finally, new stall configurations continue to be introduced, and some of them fail to provide for the comfort and spatial needs of cows.

We believe there is a need for a stall evaluation system based upon functional needs of the occupying animals for space to rest and to accommodate movements associated with rising. While some of the requirements of good stalls are related to cushion, many stall problems do not accommodate the rising motion. It is commonly said that cows rise with their rear legs first. While true, there are several critical motions that precede that step as shown in Figure 1. Cows first pull

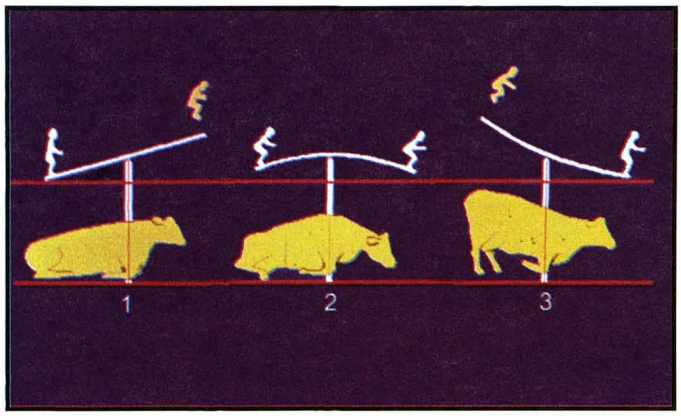

Figure 1. Schematic drawing of the cow using her carpi as a fulcrum on which to transfer weight. (Adapted from Schnitzer, 1971)[18]

their front legs caudally and elevate themselves upon their carpi. The carpi act as a fulcrum as the cow lunges forward and "bobs" her muzzle downward, transferring weight forward. She then rises completely on her rear legs and completes the motion by extending her front legs forward and then stepping backwards until the front legs are vertical. Failure to allow for all of these movements can result in entrapment, stall refusal, or reduced stall usage.

Freestall Evaluation

We have developed a system to evaluate four critical points: 1) adequate surface cushion, 2) adequate body resting space, 3) lunge room for head thrust and an unobstructed "bob-zone", and 4) adequate height below and behind the neck rail. The system has been converted into a sequential flowchart shown in Figure 2. All four factors must be considered together as many stalls have multiple deficits, such as the stall in Figure 3, and correction of a single flaw will not solve a usage problem.

The system has evolved from our clinical investigations where poor stall usage was recognized and quantified using a variety of tests, which included determining the proportion of cows with hock abrasions, the proportion of cows standing in stalls and culling rates for entrapment deaths and broken legs. The approach assumes that ventilation of the building and stalls is adequate. Several clinical experiences have shown poor usage of excellent stalls during periods of poor ventilation.

Resting surface cushion

The stall surface must be comfortable enough to attract a cow to lie down in the stall rather than elsewhere. In our opinion, surface cushion is the single most important factor in determining stall usage. The surface should be soft and moldable from front to rear. Many deficiencies of stall design will be tolerated if the bed is soft and comfortable.

Surface cushion has a dramatic effect on the time that cattle spend resting. Lying times in freestalls of 14 hours per day have been reported for deep straw beds, in contrast to only seven hours per day on unbedded concrete.[4] A recent study of grazing cows at pasture reports daily lying times of 10.9 – 11.5 hours per day.[17] Singh *et al*, studying cow behavior on straw-bedded packs, suggested that a minimum of 10 hours' lying time per day should be considered proper rest for a dairy cow.[19]

In many modern dairy facilities, the only alternative surface to the stall is concrete flooring. If the stall surface is hard and reduces lying time, the cow will spend increased time standing and walking on concrete, increasing the risk of developing laminitis.[5,6,11]

There are no descriptions of objective tests to assess stall cushion, traction and conformability. However, two subjective "knee tests" have been used to assess surface cushion. First, the surface should be moldable to your knee as you kneel on the stall. Second, rise slightly from the kneeling position and drop to your knees to the stall surface to assess the depth of the cushion.[14]

Many materials can be used satisfactorily to provide cushion, but the bedding material may potentially support bacterial growth and become a risk factor for mastitis. Sand is the preferred bedding material.[2,7] Other inorganic materials such as crushed limestone or gypsum can be acceptable, but have the disadvantage of becoming compacted and hard if the stall becomes wet. Organic materials such as wood shavings, sawdust, sunflower hulls, chopped straw, shredded newspaper, and long straw can be very satisfactory in terms of comfort, but these materials will support bacterial growth and increase the risk of mastitis if moisture is present.

Whatever the material, loose bedding must be maintained clean, dry, and to a minimal depth of six inches (15.2 cm) over concrete.[2] Bedding on top of a flat platform is easily dragged off as the cow moves about, making the rear platform hard and a risk factor for hock abrasions and crushing teat injuries. Improved retention of loose bedding is achieved by the use of a bedding retainer – either a section of 3-inch (7.6 cm) PVC pipe running along the rear lip of the stall, or a modified curb. The disadvantage of a bedding retainer is that it can also retain milk, urine and feces if improperly positioned and if the base is impermeable to drainage.

Thick rubber crumb-filled mattresses and the newer, thicker air pocket or foam-filled mats can provide an acceptable level of cushion over the entire stall surface, and require less maintenance than sand stalls. However, at least 3 inches (7.6 cm) of loose bedding on the surface is recommended to reduce friction and absorb moisture to avoid hock damage and maintain udder health and cow hygiene.[2] Bare concrete platforms

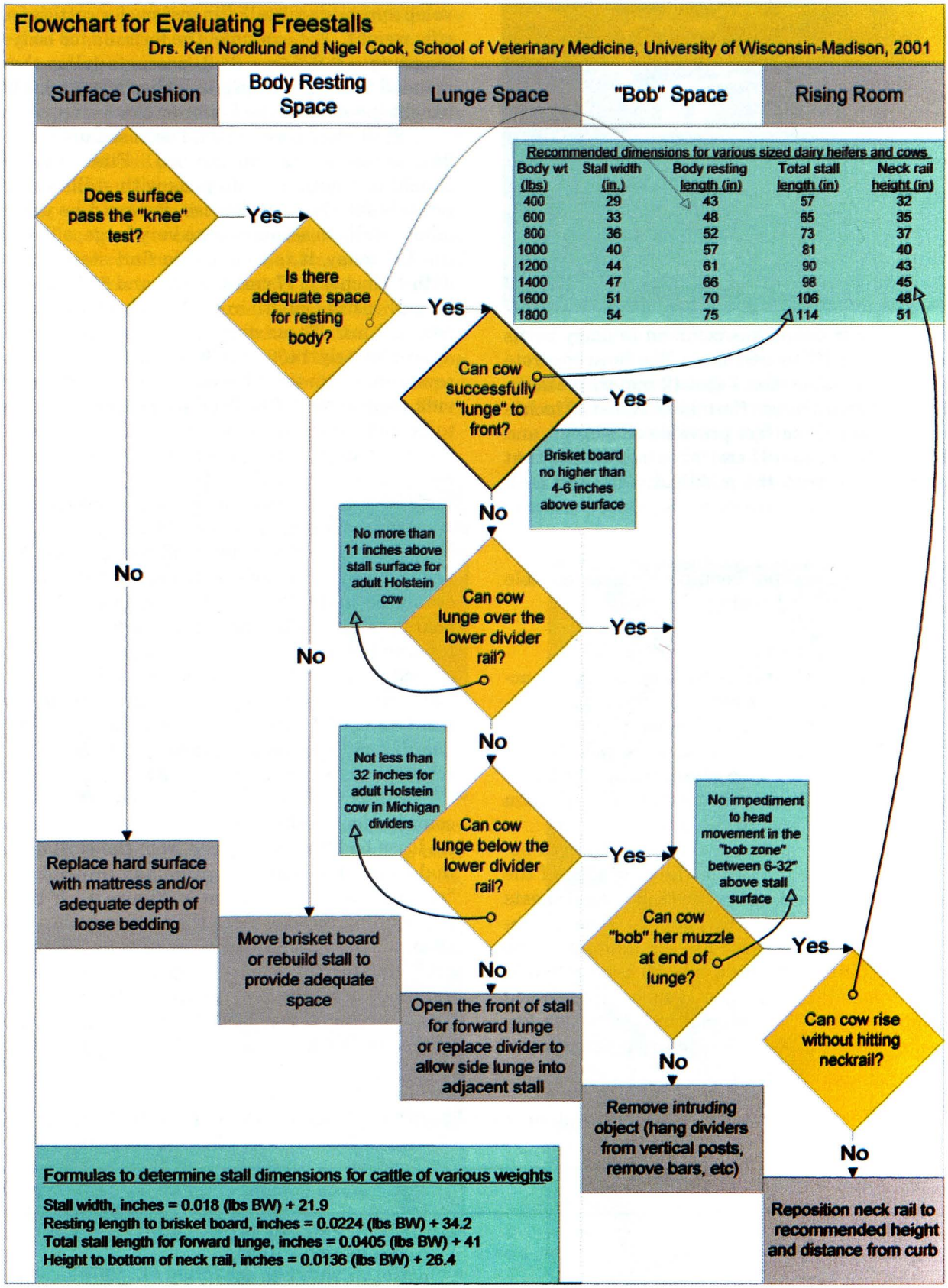

Figure 2. Flowchart for evaluating freestalls. Reprinted by permission from the May 25, 2002 issue of *Hoards Dairyman*. Copyright 2002 by W.D. Hoard & Sons Company, Ft. Atkinson, Wisconsin.

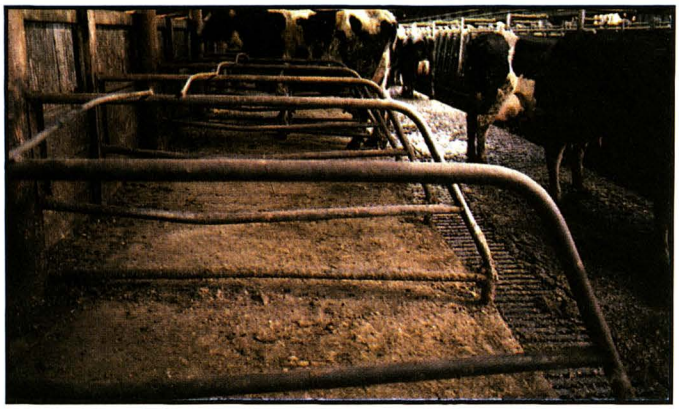

Figure 3. This freestall was common in dairy barns constructed in the 1970s and 80s. The bare concrete surface is unacceptable, the 7-foot (2-meter) platform does not allow forward lunge, the middle rail at 20 inches (51 cm) above the stall surface prevents side lunge, and the neck rail at 36 inches (91 cm) is too low. Notice that the cows have bent both the middle divider and neck rails.

or solid rubber mats without bedding are unacceptable surfaces for the humane housing of cows.

Adequate body resting space

The stall platform needs to be large enough to accommodate the resting cow's body. Defining this resting space in the front with a "brisket-board" helps to position the cow properly within the stall, reducing fecal contamination on the rear platform and the likelihood of entrapment in the front of the stall. The platform should slope about 4% toward the rear.[2]

The body resting space is defined as the area between the stall divider rails from the rear edge of the stall platform to the point where the stall surface meets the brisket board. The body resting space does not include space for the cow's head nor for lunging in the rising motion. Using data from several current publications, recommended stall dimensions were regressed against body weight.[2,9,13] The resulting regression formulae are presented in Table 1, and can be used to develop appropriate stall dimensions for cattle of any specific weight. For example, the formula for body resting length ($y = 0.0224x + 34.2$) presents {y} as the recommended total stall length in inches when {x} is the body weight (pounds) of the heifer or cow.

Stall dimensions should be based upon the largest 25% of the animals in the pen. First-lactation cows should be separated into pens with stalls sized appropriately for them. Likewise, it would be desirable to adjust stalls to accommodate very large, older cows. In the US today, it is common to find stalls constructed with 46 inches (117 cm) of width and 66 inches (168 cm) in body resting length in stalls with a total length of 7.5 feet (2.3 m). These dimensions accommodate cows to approximately 1400 lb (636 kg) and require that most cows lunge into the adjacent stall when rising. To provide comfort for 1,700 lb (773 kg) cows, stall sizes need to be substantially larger than the standard installations of today. These guidelines are compatible with recent recommendations for large Canadian cows.[1] A table of recommended stall dimensions for commonly sized animals is presented in Figure 2.

The brisket board should not protrude above the bedded surface by more than 6 inches (15 cm), and preferably be limited to about 4 inches (10 cm). Brisket boards of excess height can prevent the cow from extending her front leg forward while resting, as well as extending her front leg forward as she completes the rising motion. If too high, it will interfere with the forward "lunge" motion described below. While wooden boards can be acceptable, flexible plastic barriers with rounded edges are more comfortable for cows.

Stalls with adequate body resting space can become inadequate because of failure to maintain bedding. As loose bedding is removed from the stall during normal usage, the rear curb gradually protrudes into the "resting surface" as shown in Figure 4. If the level of the bedding recedes more than a few inches below the curb, the net resting area is reduced by the width of the curb, making the stall unusable for some animals. In addition, the "dug out" resting surface increases the height of the brisket boards and the stall divider rails above the bed as shown in Figure 5, potentially creat-

Table 1. Regression equations for the calculation of stall dimensions to meet the requirements of body size and weight.*

Measurement, inches	Regression formula	r^2
Stall width	0.018 (lb BW) + 21.893	0.9283
Body resting length, curb to brisket board	0.0224 (lb BW) + 34.203	0.8391
Total stall length for forward lunge	0.0405 (lb BW) + 40.992	0.8684
Height below neck rail	0.0136 (lb BW) + 26.362	0.9211

*Data combined from several sources[2,9,13]

ing impediments to rising that will be detailed in the "lunge and bob" section of this paper.

Protruding rear curbs are a risk factor for medial hock ulcers of cattle. While the length of the bed may not be adequate for the cow to lie parallel to the divider, there may be adequate length on a diagonal between the brisket board and protruding curb. From the diagonal position, the upper rear leg will extend across the protruding curb out into the alley, and the full weight of the leg will rest on the bony prominence of the medial hock on the concrete curb. In a dramatic case in a herd of 900 milking cows, approximately 150 cows had developed medial hock ulcerations, as shown in Figure 6, and three cows had died of resulting infections. The sand-stall bedding crew had neglected the stalls during spring cropping activities and the problem developed during late spring. Upon diagnosis, the stalls were filled, no new cases were seen, and the individual cow hock problems resolved over the next 6 weeks.

Figure 4. Failure to replace sand has caused the rear curb to protrude and shorten the effective resting body space, resulting in the heifers refusing to use the stalls.

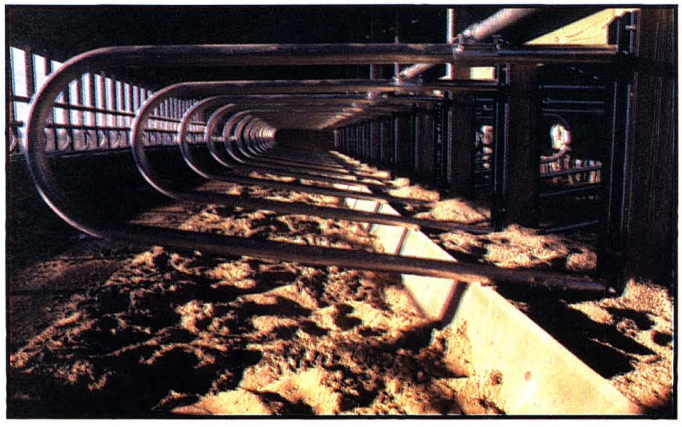

Figure 5. Failure to maintain sand has resulted in a fully exposed 2" x 12" (5 x 30 cm) brisket board, resulting in impediments to the "lunge and bob motion" and to the forward extension of the front legs.

"Lunge and bob" room

Total stall length should accommodate the body resting space requirement for the cow plus the "lunge and bob" space required for rising. Photographic analysis of mature cows rising on pasture indicates that a forward lunge space of 27-39 inches (69-99 cm) is used in the rising movement.[4] A separate component of the forward lunge is a downward "bob" as the cow's head reaches full extension. A 1400 lb (636 kg) Holstein cow would need 66 inches (168 cm) body resting area plus 27-39 inches (69-99 cm) of unobstructed forward lunge area for a total stall length of 7.75-8.75 feet (2.4-2.7 m). Total stall lengths appropriate for specific groups can be calculated using the regression formula in Table 1.

If any impediment prevents the forward lunge and bob, the cow must lift more weight with her rear legs. If the foot slips, this will contribute to bedding loss from the stall and possible injury to the cow.

Figure 6. Medial hock ulceration related to pressure sores from leg lying across the rear curb in dug-out stalls.

If the recommended total length is not available, the stall can be modified in one of several ways. First, the front of some stalls can be opened so that cows can lunge their heads forward through the barrier. It is a common practice to construct two rows of stalls of inadequate total length adjoined "head-to-head" with the assumption that the cows will lunge into the headspace of the stall to the front. Where two rows of short freestalls are arranged head-to-head, the combined length of the two stalls should be at least 15 feet (4.6 m) for Holstein cows. In one barn with facing stalls of a combined length of 12 feet (3.7 m), cows would not usually share head space and the opposite stall was frequently unoccupied.[13]

The more common modification of short stalls is to provide a stall divider that allows the cow to lunge to the side into the adjacent stall. The most common design requires that the cow lunge between two rails and is called a "wide-span" divider, shown in Figure 7. It is recommended that the lower rail be no higher than 11 inches (28 cm) above the stall surface and the upper rail should not be lower than 40 inches (102 cm).[2] We have published a clinical report where a lower divider rail was raised to approximately 18 inches (46 cm) and resulted in significant increases in rates of mastitis and culling or deaths due to injuries and entrapment.[15] Cows became entrapped because they could not successfully lunge either over, as in Figure 8, or below the divider, as in Figure 9.

Another variation of a side-lunge divider is the "Michigan" divider, designed to allow a cow to lunge below the lower rail. For adult Holstein cows, there should be 32 inches (81 cm) of clearance below the lower bar where the lunge occurs.[2] Brisket boards are not usually recommended with this particular divider as they may intrude into the lunge space. In our experience, it is common to find these dividers hung too low, as in Figure 10, making it difficult for cows to rise and resulting in poor stall usage.

Figure 7. Cows that use side-lunge stalls tend to lie on a diagonal and defecate on the outer corners of the stalls.

Stall designs that require side lunging should be viewed as a compromised situation at best. Cows that must side lunge in stalls tend to position themselves along a diagonal across the stall bed, as in Figure 7, and tend to defecate on the outer corners of the stall platform, resulting in poor udder hygiene.

While there is a general awareness of the need for lunge room, we frequently find that the "bob-zone" is compromised. The bob-zone is the portion of the lunge space from a few inches above the stall bed to about 30 inches (76 cm) high. Sometimes this space is filled with reserves of bedding. Another infringement of the bob-zone sometimes occurs with a construction technique of mounting the stall dividers on transverse horizontal pipes, as shown

Figure 8. This cow is becoming entrapped in a 7.5 foot (2.3 m) stall after unsuccessfully trying to lunge over a rail that measured 18 inches (46 cm) above the bed near the brisket board.

Figure 9. This cow is entrapped after trying to lunge below a lower divider rail that measures 18-20 inches (46-51 cm) above the mattress. The head-to-head stall dividers are mounted on a horizontal rail that intrudes into the bob-zone at 11 inches (28 cm) above the stall bed.

Figure 10. Poor stall usage where Michigan dividers allow only 24 inches (61 cm) of height in the lunge space below the lower rail. The neck rails are also low at 38 inches (97 cm) above the platform.

Figure 11. These dividers are mounted on a horizontal rail that intrudes into the bob-zone in these 7.5 ft (2.3 m) stalls. The lower rail of the divider reaches 10 inches (25 cm) above the mattress, which allows side lunging.

in Figure 11. If the total stall length does not allow for a full forward lunge behind the pipe, the bob-zone will be compromised and result in reduced stall usage. The dividers should be mounted on vertical posts to avoid forward obstructions in this zone.

Our clinical experience suggests that many stall usage problems result from efforts to utilize short stalls. Costs of about $13 per square foot for new freestall barn construction is typical in Wisconsin over the past few years.[10] Increasing the length of a stall by 1/2 to 1 foot (15-30 cm) in length will add 2 to 4 square feet per stall, increasing the building cost by $26 to $52 per stall, or about 2-4% of the overall barn cost. Amortized over the life of the building, this is a modest cost compared to the problems frequently realized with stall beds of inadequate length.

Room to rise below the neckrail without obstruction

The neck rail acts to provide lateral structural support for the dividers, and helps position the cow while standing in the stall so that she does not soil the stall platform with urine and feces.[2] A cow should be able to rise without hitting the neckrail, and a polished underside indicates that it is incorrectly located.

As measured from the rear curb of the stall, the neck rail should be positioned forward at a distance equal to the body resting length or more. When a brisket board is used, the neck rail should be positioned directly above the board or further toward the front.

Recommendations for height of the neck rail vary considerably. Traditional recommendations have located the neckrail at a height 6-10 inches (15-25 cm) below that of the withers. For example, in a Holstein herd where first-lactation cow wither height may average 54 inches (137 cm) and older cows average 56 inches (142 cm), the neck rail might be positioned 46 to 48 inches (117 to 122 cm) high. Neckrail heights can be calculated for specific groups using the regression formula in Table 1.

Miscellaneous issues

Curb height is considered an important factor in stall design in Europe. Several studies show a relationship between high curb heights and an increased risk of lameness.[8,16] We have a clinical experience in one barn with curbs of varying heights suggesting that first lactation cows prefer the stalls with the lower curbs.

While the current European curb height recommendation is 6 inches (15 cm), we have yet to see a freestall barn constructed in the US with stall curbs of this height. In US barns, higher curbs of 8 to 14 inches (20 to 36 cm) are constructed to prevent alley manure scraping or flushing from soiling the stalls. Lower curbs may require more frequent alley scraping, or cleaning in shorter stretches. Water volume issues may also be a concern in flush systems.

Stalls with inadequate curb height sometimes allow cows to easily back into stalls and lie down, resulting in badly soiled beds. This problem can also result from stall dividers that are too short and allow cows to walk along the rear of the beds, contaminating them with manure. The rear edge of the divider should leave no more than 9 to 12 inches (23 to 30 cm) to the rear of the stall platform to prevent this behavior.

Conclusions

Dairy cow freestalls can be evaluated satisfactorily on four points that reflect the movement of a cow into, down, up and out of the stall: surface cushion, adequate body resting space, "lunge and bob" room, and

rising space below the neckrail. All of the factors must be considered together, as many stalls have multiple deficits and correction of a single flaw will not solve a usage problem. Correction of stall deficits can increase cow resting time and cleanliness and have a substantial positive effect on dairy cow health, longevity and productivity.

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Abstract

A Strategy for The Eradication of Bovine Virus Diarrhoea Infection

Monies R.J., Allcock J.G., Head J.C.S.

Cattle Practice (2002) 10(2):95-99

In this journal two years ago one of the authors described an outbreak of respiratory disease caused by bovine tuberculosis in 13 of a group of 22 young calves (Monies R.J. 2000). The outbreak also involved a small number of adult cows showing a range of lesions including tuberculous mastitis. The investigation carried out at that time concluded that the calves had been infected by feeding the calves milk infected with *Mycobacterium bovis*. Nevertheless, the disease was remarkable in so far that it showed high morbidity, rapidly developing pathology and produced extensive lesions in animals of a young age (between 1-3 months). Three of the same group of calves showed central nervous signs which suggested that they had been challenged with Bovine Virus Diarrhoea (BVD) virus *in utero*. All 22 calves were slaughtered as TB reactors; post mortem followed by histological examinations of tissues showed cerebellar changes confirming *in utero* BVD challenge to the developing foetus. Laboratory investigations also demonstrated that more than one of the calves were persistently infected (PI) with BVD virus. At the time it was suggested that acute BVD infection of cohorts by contact with PI animals may be accompanied by a phase of leucopaenia and this may result in immunosuppression. This phase, it was suggested, could allow rapid progression of the disease process of other infections (Potgieter *et al* 1984).

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