

# **Facility Design to Optimize Transition Cow Comfort with Emphasis on Confinement Systems**

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## **■ Take Home Messages**

- Achieve the circles of excellence for the cow and heifer (Figures 1 and 2).
- The transition cow facility design should become the tool that allows implementation of the management plan, rations, and labour saving designs that allow the cow to express her full genetic potential.
- Determine the desired transition cow management groups to optimize cow comfort and minimize environmental and social stresses on the cow.
- Design the transition cow barn to provide adequate space to allow excellent management of the cow and heifer during the transition period.
- A well-designed facility should be labour efficient, economical, safe for both workers and cows, and environmentally friendly.

## **■ Introduction**

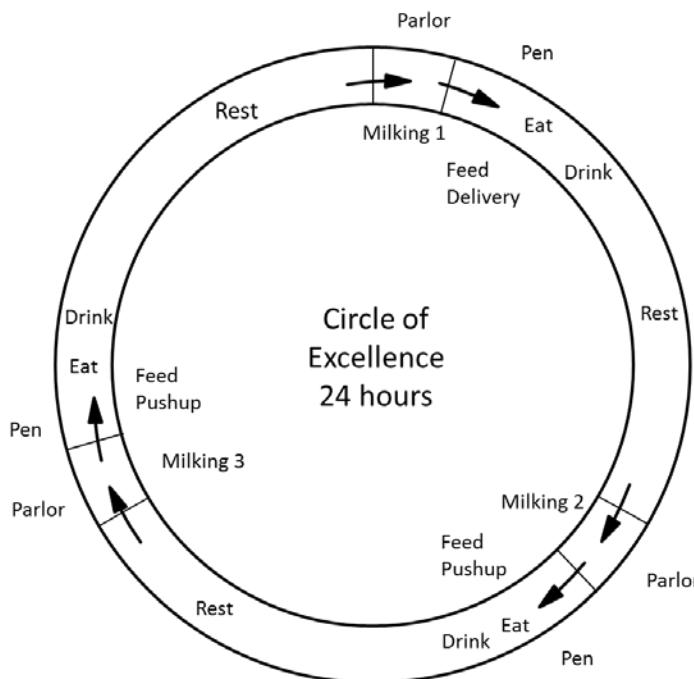
The size of dairy herds is increasing, and herds are typically managed in total confinement systems with improved management plans to provide cow comfort, labour efficiency, and profitability. Dairy farms with herd sizes of 400 to 4,000 cows are commonly turnkey dairy system designs. An important part of the dairy confinement system is the transition cow facility. Transition cow facility design should facilitate implementation of a management plan and protocols developed by the dairy team that allow the cow to express her genetic potential. As herds become larger and management demands for improved cow care increase, transition cow groups emerge. Properly designed facilities should consider cow comfort, worker safety and labour efficiency for managing and caring for these cow groups.

Many producers and agricultural professionals are recognizing that managing the transition cow groups more intensely can have a significant impact on

total herd health and performance during the subsequent lactation. Recent research and field experience also are identifying the importance of considering the cow's social behavior and comfort in the facility design to minimize the associated metabolic and production problems that occur with the decreasing dry matter intake (DMI) of the cow as she gets close to calving. Building designs should be sensitive to these needs and flexible enough to accommodate changing management requirements.

## ■ Achieving Three Circles of Excellence

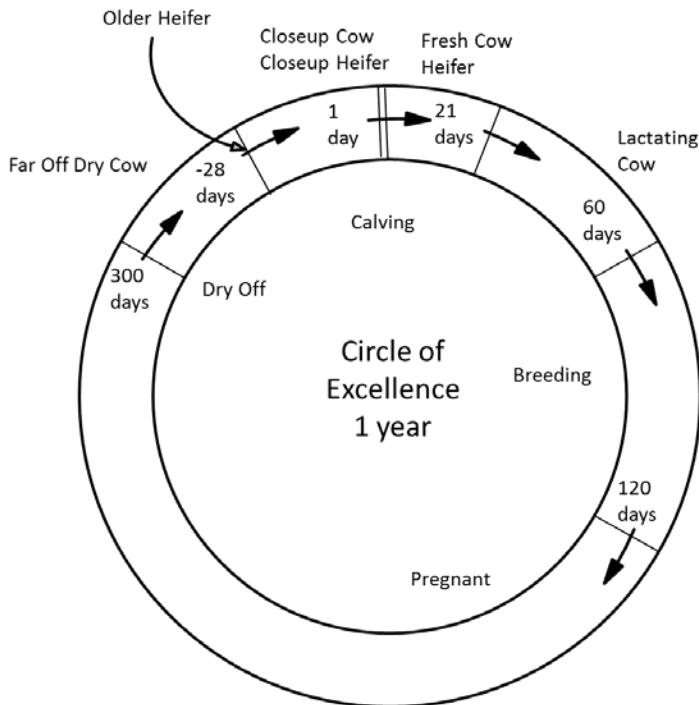
The dairy management plans and protocols should consider three circles of excellence. Figure 1 represents the circle of excellence in the 24-hour period of the cow's life and is commonly referred to as the cow's time budget. The time budget focuses on maximizing the lying time for the cow by creating a daily routine that enhances DMI earlier in the day and minimizes time forced away from the pen to optimize time to eat and rest.



**Figure 1. Circle of excellence for 24 hours in the life of a cow.**

The second circle is the life cycle from the birth of a heifer calf to the time she enters the herd. This is associated with the housing and management of the replacement heifers. The heifer raising system focuses on proper growth of

the heifer so that she is at the correct size and age at breeding and at calving time to minimize health problems during the first calving. In the transition cow management plan, the time that the heifer is introduced into the milking herd leads to the final circle.



**Figure 2. Circle of excellence for one year for a cow.**

The third circle of excellence (Figure 2) is the annual cycle of a cow or heifer starting from the dry period or introduction of the heifer into the herd and follows her through calving, breeding, lactation, and finally drying off to repeat the cycle.

The transition period refers to the two to three weeks before calving, the calving process, and the two to three weeks after calving. This is the time in the cow's or heifer's life that presents the greatest risk of her developing a health problem. The focus of this paper is the management of the transition cow or heifer and the transition cow facility design to optimize cow comfort and performance at this important time of the cow's or heifer's life cycle.

The main goal in the design of a transition cow facility is that the facility should become the tool that allows the implementation of the management plan, rations, and labour saving designs that allow the cow to express her full genetic potential. The transition cow management plan and protocols are developed by the dairy management team that commonly includes the following members:

- Owner
- Herd manager(s)
- Employees
- Agricultural professionals
  - Veterinarian
  - Nutritionist
  - Dairy designer
  - Agricultural engineer
  - Builder
  - Equipment dealer

Decisions on the design features and specifications for the facility design will be based on the transition cow management plan and the protocols developed. A well designed facility will include the desired features to create a functional, cow comfortable, and labour efficient facility.

## ■ Transition Cow Facility Design Steps

When the management plan is developed it will be used to develop the facility design and pen layout. To achieve a practical facility layout design several steps are followed that include:

- Define the transition cow management plan
- Determine the management plan at time of calving
- Define transition cow management groups
- Determine the number of cows in a management group
- Design group pens for optimal cow comfort
- Arrange pens into a facility design
- Design for labour efficient cow movement
- Determine additional design features

## Define the Transition Cow Management Plan

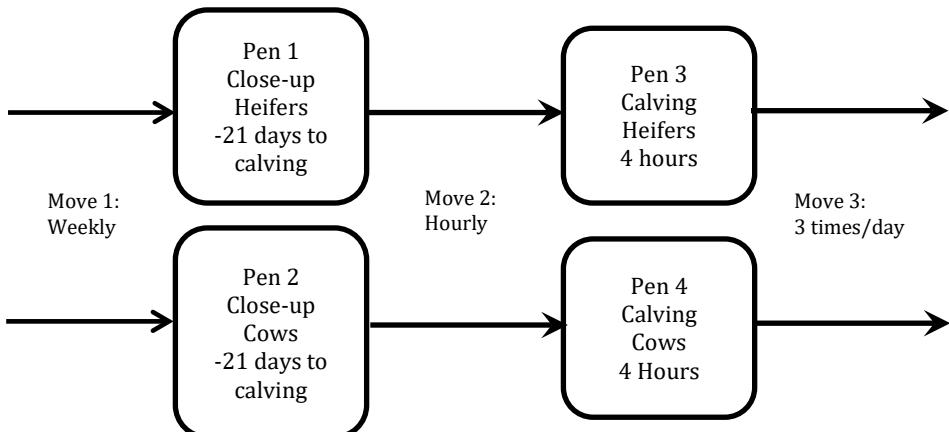
The transition cow management plan must identify facility features and include facility design decisions that will ensure successful implementation of the plan.

## Determine the Management Plan at Time of Calving

Frequency of observation and intensity of management of the close-up cow group also will impact building design. Several options exist for managing the close-up cow groups.

### *Just-in-Time Calving Management*

It is common for large confinement herds to milk around the clock, whether two or three times per day, with managers moving cows night and day. This allows almost continuous or hourly observation of the close-up pen to identify actively calving cows in what is commonly referred to as “just in time” calving management. Figure 3 shows this pen arrangement. When observed and at the correct time, the individual cow or heifer is moved from the close-up group pen to the calving pen to complete the calving process in a clean dry well-bedded environment.

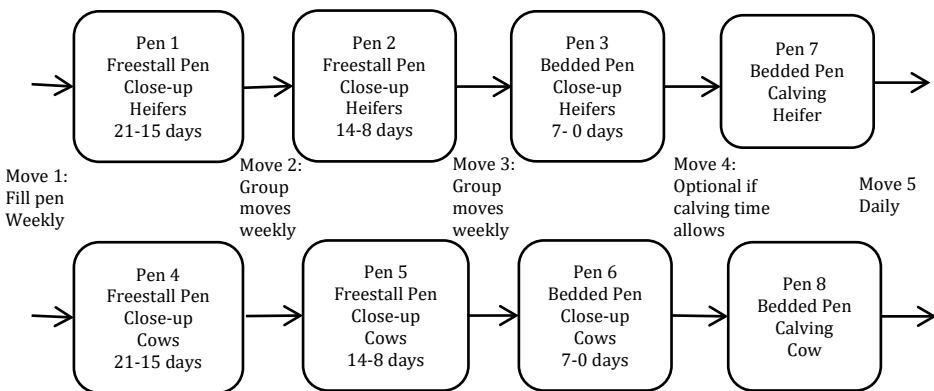


**Figure 3. Just-in-time calving management.**

### *Socially Stable Group Calving Management*

For smaller herds that lack around the clock monitoring of the close-up cows, the building design and management should account for the likelihood that there is infrequent monitoring (more than four hours) of the close-up cows or heifers. In this case, close-up cows or heifers should be housed in a well-bedded group to reduce risk that the cow or heifer will calve in a freestall pen.

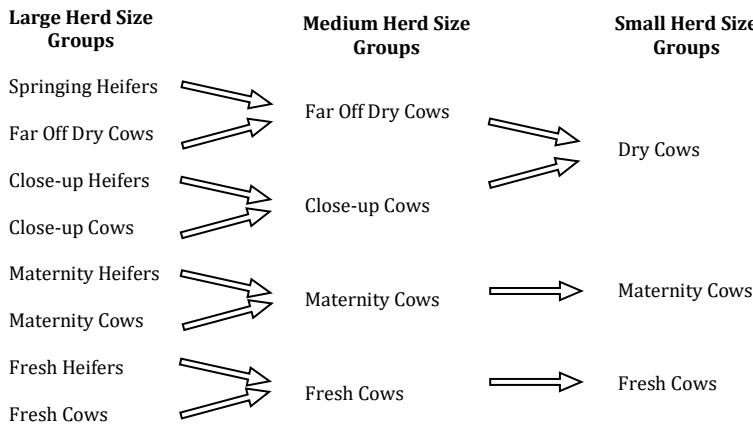
Figure 4 shows the arrangement for socially stable group calving pens. A common system is to use three pens of seven days capacity: 21 to 15 days, 14 to 8 days, and 7 to 0 days (day 0 = day of calving). Cows and heifers are moved into the pens weekly with no new cows or heifers added to the pen. Groups are moved into the next closest to calving pen weekly. All three pens could be bedded group pens, or the first two pens furthest from the calving date could be freestall pens and the last pen could be a bedded pen. In the last pen the cows leave after calving but no other new cows are introduced into that pen during the week. Cows observed to be actively calving can be moved into an individual calving pen. This system ensures that if a cow calves earlier than expected she would calve in a clean well bedded group pen. When pens are empty they can be cleaned before the next group is moved into the pen.



**Figure 4. Socially stable group calving management.**

### ***Define the Transition Cow Management Groups***

Transition cow management groups and the number of animals in each group must be defined for a specific farm's transition cow management plan. Transition cow management groups are determined based on the ability to house, feed, and manage the group of cows with similar needs in a functional pen size. The pen could be a group of cows or heifers, or a mingled group of cows and heifers. Figure 5 shows the typical management groups and the possible consolidation of appropriate cow groups as herd size decreases.



**Figure 5. Transition cow management cow groups for large, medium, and small herds.**

For a large herd the number of cows in a specific management group may be large enough to justify an additional pen. For example, it may be practical to separate heifers from cows during their close-up transition period and subsequent lactation. Separation minimizes the social stress of grouping and social order or ranking that occurs when younger or submissive cows are introduced into a pen. On the other hand, as the herd size decreases the number of cows in a specific management group may get so small that a separate pen for those cows is not practical; in this case it may be necessary to consolidate groups. For example, in a medium-sized herd, the springing heifers and far-off dry cows might be mingled into a pen or the close-up cows and heifers might be mingled into a pen to create a practical pen size. Compromises of consolidating these groups are determined by the transition cow management plan.

### ***Determine the Number of Animals in a Management Group***

The number of cows in a transition cow group depends on herd size, calving interval, reproductive efficiency, culling rate, and the time period the groups are housed. Dairy herd management records are the first and best data that can be used to determine the number of animals in a management group pen. A weekly or monthly report of cows calving, heifers calving, and total calvings from a herd management software package during a 12 to 24 month period will help in developing realistic numbers for each management group. When individual farm calving records are not available, the design assumptions can be based on data available from dairy herd summary databases. If no herd or summary records are available, the next option to determine group sizes is to

use assumed herd table values or equations from sources such as extension handbooks.

The time period within a pen for a management group is based on recommended practices and experience and should be defined in the transition cow management plan. The number of days' capacity for each management group such as far-off dry cows, springing heifers, close-up cows or heifers, calving pen, and fresh cows are used to determine the group or pen size. Common recommendations vary from seven to 28 days for the close-up cows or heifers and fresh cow groups.

### ***Designing the Pen for More Than the Average Need***

The most common mistake in transition cow facility design is having inadequate space to properly manage and care for the cows during the transition period. Far too often with inadequate pen space, some cows are forced to move out of a pen too early to accommodate the new cows that need to enter the pen, or the pens are overcrowded with inadequate space for cows to eat or rest. Overcrowding may be of most concern for the submissive cows in a large group who may not be able to compete for feed at the bunk or be able to lie down because the resting space is full. This creates a situation where the management plan cannot provide the goal of optimizing cow comfort and providing excellent cow care. Inability for management to implement the desired management plan because of inadequate pen space creates many of the metabolic and health-related problems that could be minimized with adequate space in the facility design.

The natural biological and seasonal variation of the reproductive cycle for the dairy herd over time should be accounted for in the pen design capacity. Facility design should accommodate a conscious design decision to provide adequate space to accommodate the herd's calving cycle, especially at peak calving periods for the planned herd size now and consider future potential growth of the herd. Designing the group (pen) capacity based on the average weekly or monthly number of calvings is not adequate and creates a situation where the transition cow pens are overstocked for half the year.

Several sources recommend that the transition cow group pens be sized to meet the pen space needs for 90% of the year. For example, using herd data of weekly calvings the 90<sup>th</sup> percentile of calvings would be used as the minimum group or pen design capacity. Pen capacity designed for the 90<sup>th</sup> percentile will meet the needs for 47 of 52 weeks. For the other 5 weeks (10%), the pen can be managed by adjusting the time period that the cows are in the pen. For example, cows that are doing well could be removed in preference for cows coming into the pen to avoid overcrowding. This maintains the priority of having an adequate feed and resting space for all the

cows in the pen rather than overstocking the pen and affecting the entire group.

When herd management data are not available, the estimate to meet the 90<sup>th</sup> percentile need is to plan for a pen size of 140% of the average weekly calving rate. Several planning tables have been developed to determine the pen size design numbers based on a specific herd's calving data. Table 1 is a summary for common transition cow management groups, the time periods in a pen, and the group size recommendations for a herd size of 1,000 cows.

**Table 1. Transition cow management group sizes for a 1,000 cow dairy<sup>1</sup>**

Transition cow management group <sup>2</sup>	Days in pen	Group size design value (140% of average)
Far-off dry cows	22 to 60	100
Far-off heifers	22 to 60	52
Close-up cows	21	55
Close-up heifers	21	29
Calving pen	1	4
Fresh cows		
2 or more lactation	14	37
First lactation	14	19

<sup>1</sup> Adapted from School of Veterinary Medicine Transition Cow Pen Size Calculator (<https://thedairylandinitiative.vetmed.wisc.edu/index.htm>).

<sup>2</sup> Assumes milking herd with 34% of cows in their first lactation.

## Design Group Pens for Optimal Cow Comfort

Optimizing cow comfort for each group and minimizing cow stress are the main goals for the transition cow facility design. Pen design philosophy for transition cows is different than for typical lactating cow pens. The tendency in lactating cow pen design is to maximize the resting space or freestall utilization with the possibility of limiting feed space. Research and field experience, however indicates that when designing for transition cow groups, an important design principle is to provide more than adequate access to feed and resting space. Extra feed and resting space and wider traffic lanes all help provide optimal cow comfort and minimize the typical decrease in DMI that occurs as cows go through the calving period. Inadequate feeding and resting space can result in metabolic problems, injuries, and stress that keep the cows from entering the milking herd at the appropriate time and in the best condition possible.

## ***Optimal Cow Comfort***

Optimal cow comfort can be best accomplished by incorporating current recommendations for the design of the space and environment around the cow. To provide optimum cow comfort and cleanliness for the transition cow, the resting space should be clean and dry while providing adequate space for the cow. There are two main resting spaces that can be used for transition cow groups.

### **Freestall Cubicle Space**

Recommended freestall dimensions depend on size and breed of the cow. Several sources of good information are available that describe design and dimensions for a properly sized freestall cubicle ([https://www.vetmed.wisc.edu/dms/fapm/fapmtools/5house/Update\\_to\\_Stall\\_designAABP.pdf](https://www.vetmed.wisc.edu/dms/fapm/fapmtools/5house/Update_to_Stall_designAABP.pdf) and <http://www.omafra.gov.on.ca/english/livestock/dairy/facts/freestaldim.htm>). In general, freestall dimensions are larger than the average of the herd size, because late-gestating cows are larger with calf and less mobile. The freestall platform should be easily accessible from walk alleys and provide a clean and dry place for the cow to rest. A deep-bed sand base is an excellent bedding choice for transition cows because it provides a clean dry resting surface with good footing to ease the rising and lying motions of the cows.

### **Group Bedded Pen Space**

The bedded resting area should be a minimum of 100 sq. ft. per cow with 120 to 150 sq. ft. recommended. This resting space does not include the alley space used for accessing feed and water. Adequate space in a bedded pen and plenty of bedding can increase the comfort and cleanliness of the cow without the necessity of intensive and frequent grooming and cleaning of the pen. More densely populated bedded pens require more frequent grooming, bedding addition, and cleanout to keep cows clean and comfortable. Bedding should be added regularly to provide a clean and dry place for cows to lie and calve.

### **Individual Bedded Pen Space**

Individual calving pen space should provide 150 sq. ft. per cow of resting space. The base of the pen may be concrete, clay, or sand. Although concrete floors are more easily cleaned, they may not provide the best footing surface. Clay, dirt, or sand bases allow better footing and allow relatively easy cleaning of the pen when accessed by a skid steer. At least six inches of long straw should be placed on top of the base. Bedding and manure accumulation should be removed and replaced with fresh dry bedding after every calving.

### **Feed Space**

Providing adequate feed space and minimizing competition at the feed bunk is an important design principle in the transition cow pen. Pen design should

not create any limitations on feed intake. Current recommendations are that the transition cows should have access to 0.75 m (30 inches) of bunk space with head locks spaced at 0.75 m (30 inches) or with 0.60 m (24 inches) headlocks stocked to only 80 to 85% of the feeding space capacity regardless of the number of stalls in the pen. This may not be as important when a high fibre-correct energy (Goldie-Locks diet) ration is fed.

Headlocks allow restraint for management purposes and do not restrict DMI. Post and rail feeding fences can damage the cow and reduce artificially the feed space for submissive cows when a dominant cow commands more of the usable bunk space than she needs. Cows also try to stand diagonally to the feed line rather than perpendicular to the feed line taking up more space than they need.

### *Walking Space*

Alley widths should be dimensioned to provide unrestricted access to the resting space. Alley widths between freestall rows should be a minimum of 10 ft., with 12 ft. recommended. Alley width between a freestall row and the feed line should be a minimum of 14 ft. Crossover widths should be a minimum of 12 ft. plus the space for a water location. Crossovers in a pen should be located approximately every 120 to 160 ft. to provide easy access to feed and stalls. Additional crossovers create easy access to the feed bunk, increase the feed space access, and provide another location for a waterer. Strategically located double wide (32 ft.) crossovers with a waterer splitting the crossover in a pen allows the opportunity to provide a flexible pen size between adjacent pens creating flexibility in how the pen(s) are managed. Double wide crossovers allow the pen to be resized by adding gates at the waterer.

### *Water Space and Location*

The waterer should be sized to provide three inches of perimeter linear space per cow in the pen. There should be at least two water locations in each pen. Waterers are typically located at all crossovers of a freestall pen arrangement. Additional water locations can be placed on the outside wall alley during summer. In a bedded pen arrangement, the waterer is located between the feed access alley and the bedded resting space. A fence should prevent access to the waterer from the bedded resting space and only allow access from the alley side. This keeps the bedded space clean and dry. Providing water locations that can be shared by adjacent pens can provide more than one water location in a pen.

Ventilation of the transition cow facility should provide for excellent air quality. The design options vary from naturally ventilated to totally mechanical ventilated barn designs. Heat stress mitigation is a very important component of any ventilation system design for cows at this stage of their life. Provide

excellent lighting (25 to 35 foot candles) for good observation of cows and even greater light intensity (50 foot candles) in treatment and work areas.

### *Freestall Pen Designs*

Freestall pens for closeup and fresh cows are an appropriate environment for the cow up to the point of calving. A two-row freestall pen design is an efficient pen layout providing the recommended feed space per cow and a freestall platform resting space for every cow in the pen without wasting space. In a close-up pen a head to tail freestall row arrangement allows easy observation of the rear of the animals as the manager walks up the feed lane.

In a fresh cow pen, a head to head arrangement is less costly to build with four curbs rather than five curbs and one post per two stalls rather than one post per stall. Therefore, 50% of the cows can go to a stall to rest with minimal walking. A tail to tail arrangement has the benefit of allowing management the ability to keep cows standing at the bunk if desired. The outside alley is moved away from the outside cold wall and has 100% of the cows traveling in the alley, which may help minimize frozen manure. Additional crossovers or double wide crossovers may be required to provide the recommended water space and easy access to the feed-access alley because 100% of the cows must move through the crossover space to and from stalls or feed.

Freestall pen designs with three rows have limited feed space on a per cow basis and the cows will not efficiently use the resting space of the pen. A three-row pen design for the far-off dry cow and older heifer groups can be used when feed space is adequate.

One option that allows use of a three-row pen in a remodeled facility is to use the outside row of stalls as a drover lane. The drover lane may be needed to move cows from pen to pen and it allows the use of the other two rows of stalls in a properly designed transition cow pen with adequate feed and resting space.

### *Group Bedded Pen Design*

When designing a group bedded pen space use the footprint of a freestall pen space to design the pen geometry. This allows for future conversion of the bedded pen space into a freestall pen space. The feed access alley can remain as it is in the freestall pen arrangement and the space where freestall platforms would be in the future is used as bedded resting space. The pen arrangement should allow easy bedding addition and bedding-manure removal with a skid steer or front end loader.

### *Individual Bedded Calving Pen Design*

Calving pen arrangement should allow for easily moving a cow from an adjacent close-up group pen to the calving pen with one person. The pen also

should allow easy access for cleaning and bedding between calving cows. The calving pen should include access to water and a headlock with gates positioned to allow funneling the cow into the headlock for treatment and milking after calving. A vacuum line can be placed above the pen to allow milking out colostrum in the pen before moving the cow. Calving cows typically need less than 12 hours of housing in a maternity pen.

### ***Reducing Cow Moving and Grouping Stress***

Moving cows may invoke different levels of stress and impact performance. When cows are in a pen with an established social order, moving them into another social group has the detrimental effect of reducing feed intake and resting time. A pen of less than 100 cows has a social group and social order (ranking) within group. A pen of 200 cows has two social groups and social order (ranking) within each social group. Moving cows that are part of a large ( $> 250$  cows) group results in a lesser effect on feed intake, resting time, and performance.

### ***Arrange the Pens into a Facility Design***

After the individual pens are sized, the next step is to layout or arrange the pens in a facility layout that will fit the building space. Figure 6 shows a bubble diagram sketch of how the pens could be placed in a barn design. The pens may be located as desired or moved to fit into the building in a different configuration. The pens may need to be resized slightly and moved to fit into a typical building layout such as a four-row barn with pens on opposite sides of the feed traffic lane.

Lactating cow pens should be located as close to the parlor as possible, whereas pens for far-off or close-up cows can be placed further away. Bedded pens will require access for cleaning the bedded resting area without moving through freestall pens and usually are best located at the ends of the building.

Additional considerations will be manure handling system flow, feeding access, and cow movement. Another important consideration in designing a transition cow facility is flexibility. Needs vary from herd to herd, throughout any given year and throughout the life of a dairy.

### ***Design for Labour Efficient Cow Movement***

Facilities should be designed with thought given to labour requirements for performing required cow care and cow movement through the pens. The transition cow facility is where the herd manager and veterinarian will be spending most of their time. It is extremely important that working conditions are convenient for them to make the most efficient use of their time. Prompt and proper care of the cow during this critical period in a cow's annual life

cycle can be considered the foundation on which a cow builds a profitable lactation and provides a healthy replacement. A list of the working protocols or standard operating procedures and a description of the facility features that would allow the protocols to be implemented should be developed.

### *Restraint*

Appropriate animal restraint systems should be in place in the pen design. For large group pens, a headlock system is the most common. In individual pens a headlock and strategically located gates can create a funnel to allow a person to maneuver a cow into the headlock easily. Strategically located safety passes or personnel passes should be available in all pens. A gap between the bottom rail of the fence or gate and the floor will allow a person the opportunity to roll away from an aggressive animal.

### *Drover Lane*

Drover lanes or alleys are another feature that can ease the time and labour of moving cow groups from pen to pen. With a well laid out pen system and a drover lane, one person can move and manage cows. The drover lane is placed adjacent to a series of group pens along the length of the building so that any pen can be accessed. This is an especially important design feature for large herd barn designs with multiple pens in the length of the barn. The drover lane allows cows to be moved from one pen to another without disrupting the routine of other pens or needing to move cows through other pens.

### *Bud Box*

Cow movement with the ability for one person to move a cow from pen to pen should be a primary consideration in determining pen locations and drover lanes. The bud box design for moving cows into a pen from an alley or lane is one method that can make cow moving an easy task. As the cow moves down the alley she passes the pen that ultimately is her destination. As the person moving the cow moves past the destination pen, he or she closes the alley gate blocking the previous entrance. This gate also opens the destination pen the cow is to enter. When the cow reaches the dead end of the alley her tendency will be to turn and try to exit where she entered. The only option will be to enter the destination pen.

### *Worker Safety*

The facility design should be safe for cows and people. Worker safety considerations should also be part of the management and facility plan. Items to consider in the design include animal restraint measures, escape routes for workers from aggressive animals, elimination of pinch points or entrapment hazards between the worker and the animals, good footing for both workers and animals, and adequate lighting.

## ***Additional Design Features***

Several other design features should be incorporated in the barn design to support and provide a convenient work place for the herd manager and employees to facilitate the transition cow management plan and protocols to be implemented including care for the newborn calves.

### ***Herdsperson-Veterinarian Office.***

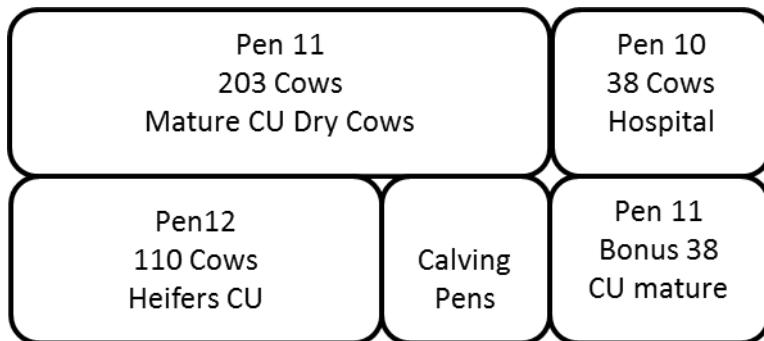
The herdsperson office should be near the transition cow management groups because this is where a lot of the herdsperson's time will be spent with cows calving and with monitoring health of the fresh cows. This office space can be located adjacent to the calving pens to allow easy access to the cows and to a computer for records. This office also may be used by the veterinarian.

### ***Calf Processing Area***

A space for working with the newborn calf should be in a convenient place near supplies and equipment that might be needed to process the calf and get it ready for its new location. Access to hot water, cleaning supplies, towels, colostrum storage, and other vet supplies would be desirable. In cold weather, a warm room and calf warming box may be necessary to dry the calf before moving.

### ***Implement the Design***

A scaled plan or sketch of the facility design should be developed. The plan is used to communicate the transition cow facility features and specifications to the dairy team and the builder. The scaled plan can be used to evaluate the overall design and its impact on all aspects of the transition cow management plan. The dairy design team can review and critique the design. The plan can be used to evaluate cow flow from pen to pen, feed equipment traffic, manure handling traffic, and transition cow management protocols.



**Figure 6. Transition cow group pens in a facility design.**

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