Recommendations for Special Needs Facilities

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Introduction

Often, when dairy producers are planning to build new dairy facilities a lot of time is spent on selecting and sizing the milking parlor and cow housing. However, often not enough effort is put into designing, selecting, and sizing special needs facilities. There are an overwhelming number of reasons from a cow health and milk production standpoint to have a well-designed special needs facility that will not be a barrier to management. The transition from a pregnant cow to a lactating cow represents the period of greatest challenge to the health and productivity of the dairy cow (Curtis et. al., 1985). The majority of metabolic and infectious disease the cow will experience will occur in the first weeks of lactation. The sudden onset of milk production outpaces the animal's ability to increase intake of nutrients placing the animal in negative balance for such vital nutrients as energy, protein and calcium in early lactation. Cows failing this metabolic challenge can develop milk fever, ketosis and displaced abomasum. The hormonal changes associated with the act of calving have a suppressive effect on the immune system of the animal increasing susceptibility to infectious diseases such as mastitis and Salmonellosis. Negative energy balance and environmental stresses can have an additive effect on immune cells and further suppress the animal's resistance to infection. To reduce disease and improve the productivity of the cow we must design facilities and strategies to maximize feed intake and reduce "stress" on the transition cow. Stress can take many forms but generally results in an increase in cortisol release by the cow, which tends to reduce immune cell function.

This paper discusses the issues associated with special needs facilities. The examples in this paper are based on a 2,400 lactating cow dairy that has chosen to use freestall housing configured in 4-row barns.

Definitions

Before proceeding into the heart of this topic it is important to define some terms. Listed below are definitions used in these proceedings.

Special needs facility — The facility and equipment needed to manage cows and heifers starting with 21 days prior to calving (close-ups) to 16 after calving (fresh cows), sick cows, and high-risk lactating cows. This facility must ensure the safety and well being of employees and minimize the stress on a dairy animal(s) due to additional interactions between the employee and dairy animal.

Close-up — Cows and heifers that are from 4 to 28 days prepartum up to but not including calving.

Maternity — The area provided for cows and heifers to give birth.

Fresh cows and heifers — Cows and heifers from calving to 16 days postpartum.

Transition Period — Twenty-eight days prepartum to 16 days postpartum.

High-risk lactating cows — Cows that produce milk that can be sold but need special attention. Examples would be lame cows, older cows, slow milkers and cows that had just been released from the sick pen.

Mastitis and sick cows — lactating and sick cows that have been treated with antibiotics.

Activities to be Completed in the Special Needs Facilities

A number of activities will need to be carried out in the special needs facilities. Numerous authors have pre-

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sented materials discussing restraining and treating cows (Bickert 2000, Bickert 1998, Hardin, et al. 1994, Veenhuizen and Graves, 1994). Table 1 lists these activities and the possible locations they could be carried out in the special needs facility. The decision to use or not to use headlocks needs to be made early in the design process. If headlocks are installed along the feed barrier, many of these activities may be carried out in headlocks. The planning team must determine how all the activities are going to be performed by the management team.

Grouping Strategies and Building Requirements

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 parlor size, 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

Table 1. Possible areas activities can be completed in the special needs facilities.

Activity	Lockups	Chute	Palpation Rail	Shipping Area	Parlor / Equipment Room	Maternity	Table
Drenching	X	X					
Injections	X	X	X				
Rectal Temperatures	X	X	X				
Urine pH	X	X					
I.V.'s	X	X					
Sorting	X	X	X				
Palpations	X	X	X				
Insemination	X	X	X				
Postmortem Exams				X			
Hoof Trimming		X					X
Surgery	X	X					
Milk Pasteurization					X		
Pulling Calves						X	
Process Calves						X	
Shipping				X			
Drying Off					X		
Treat Mastitis					X		

3. Fresh cows and heifers with non-sellable milk (0 to 2 days postpartum)
4. Fresh cows with sellable milk (3 to 16 days postpartum)
5. Fresh heifers with sellable milk (3 to 16 days postpartum)
6. Sick cows with non-sellable milk
7. High risk cows with sellable milk.

The cows in classifications 3 to 7 are typically housed in the special needs area along with close-up cows and heifers. Figure 1 illustrates how cows and heifers would move through the special needs area, starting with 21 days prepartum. Some may opt to move heifers into this facility 28 to 35 days prepartum.

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. Isolating heifers from mature cows immediately following calving is difficult on most dairies due to the small number of cows and heifers that will be 2 days postpartum at any given time. In Figure 1, cows and heifers are co-mingled for 2 days after calving.

Close-up dry cows and springing heifers differ in nutritional requirements. Close-up cows have greater intakes and are 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. Allowance in the special needs facilities must be made during the initial planning process if heifers are to be housed 28 to 35 days prepartum rather than 21 days.

Immediately (24 to 48 hours) prior to calving close-up cows and heifers would be moved into a maternity pen with a bedded pack. Following calving, cows and heifers may be co-mingled or kept separate until the milk can be sold. This is the only area in the special needs area where cows and heifers may be housed together. If the facilities allow, keeping the cows and heifers separated during this period is recommended. 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 used to house cows treated with antibiotics and a high risk pen for lame cows and slow milkers producing sellable milk. An additional pen would also be supplied as a holding area for cows to be culled, dried off, or moved to another group of cows. Generally, this is a dry lot pen, which is conveniently located near the shipping area.

Space near the maternity area is needed to process and house calves after calving. Calf housing should be provided for the number of calves that will be born in a 24-hour period or sized according to the calf grower pick-up arrangements.

Table 2 provides recommended groups, group sizes and typical housing requirements for cows, heifers and calves. It is important to realize these group sizes have been increased to account for fluctuations in calvings and cow and heifer numbers. If these pens are only sized for static or average numbers, there will be a considerable amount of time where the special needs facilities are over stocked.

Selection of Cow Housing

In a freestall dairy, cows and heifers in the special needs facilities are housed in either freestalls or loose housing. There are advantages and disadvantages to the two different housing systems. Loose housing maximizes cow comfort but requires additional space, bedding material, and labor to maintain a sanitary environment. This is particularly true when organic bedding is used. Freestalls reduce the labor cost of maintaining the resting area. Stalls may intimidate certain groups of cows and, therefore, should not be used. Some of the housing options that can be used for different groups of cows are listed in Table 2.

The data in Figure 2 is similar to recommended group sizes published by Stone (2000). Kammel et al, (2000) presented case studies of how dairy producers managed special needs facilities. The information in these case studies is similar to the information presented in Table 2.

Transition Cow Cooling

Heat stress in the transition cow may impair health, decrease milk yield, and lengthen time to peak milk

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Table 2. Recommended Groups and Facilities for Cows Housed in the Special Needs Area in a 2,880 Cow Dairy (2,400 lactating cows).

Group	Average Time in Facility	% of Lactating Herd	# of Cows	Housing System
Close-up cows	21 days	6%	144	Freestalls or loose housing
Close-up heifers	21 days	3%	72	Freestalls or loose housing
Maternity cows	3 days	.33%	8	Loose housing
Maternity heifers	3 days	.33%	8	Loose housing
Maternity overflow	3 days	.33%	8	Loose housing
Fresh cows & heifers, non-sellable milk	2 days	1%	24	Freestalls or loose housing
Fresh cows	14 days	3.5%	84	Freestalls
Fresh heifers	14 days	1.5%	36	Freestalls
Mastitis & sick cows, non-sellable milk	N/A	2%	48	Freestalls or loose housing
High risk sellable milk	N/A	2-6%	48-144	Freestalls or loose housing
Cull and dry cows	N/A	1.5%	40	Loose housing
Calf housing	24 hours		12	Hutches or small pens

production and peak feed intake. Transition cows are particularly susceptible to infectious diseases and metabolic disorders. Cost estimates of impaired health in the fresh cow range from $145 per case of clinical ketosis to $340 per case for displaced abomasum (Hoard's Dairyman, 1996). Perhaps the biggest challenge in managing the fresh cow is to get her on feed the first few weeks postpartum. Aggressive postpartum appetites minimize the time spent in negative energy balance and are necessary to support high levels of milk production.

Research reports that prepartum cooling consistently decreases rectal temperature, lowers respiration rate, and increases calf birth weight. While milk production responses have been somewhat variable, these variations may be explained by differences in duration and extent of prepartum cooling across trials. Wiersma and Armstrong (1988) reported higher peak milk production (up to 5%) in cows cooled prepartum compared to those not cooled prepartum (88.4 versus 84.2 pounds milk per cow per day for cooled and control cows, respectively). Collier et al. (1981, 1982) also reported trends for higher milk production due to prepartum cooling (either as shades or evaporative cooling systems). Field trials have demonstrated increased peak milk yield and earlier days to peak production in fresh cows cooled with evaporative cooling compared to non-cooled cows (Stokes and Pope, 1997). Likewise, cooled cows showed greater lactation persistency compared to non-cooled control cows.

The endocrine system is perhaps more sensitive to moderate heat stress during the dry period than during lactation. Prepartum heat stress affects growth of maternal tissues (mammary gland, placental, or fetal tissue), influences postpartum mammary function (Collier et al., 1982), decreases calf birth weight (as much as 10%), reduces immunoglobulin content, and lowers nutrient (fat, protein, and lactose) concentration in colostrum. Calves born during the summer suck their dams less vigorously and may have impaired absorption efficiency caused by heat stress. This lowered absorption efficiency, coupled with the lowered content of colostrum, may increase the incidence

of health complications and mortality in calves born during the summer and early fall.

Heat stress in cows prior to breeding and during the implantation phase may influence fertility. Wolfenson et al. (1988) reported an increase in both conception rate (59 vs 17%) and 90-day pregnancy rate (44 vs 14%) of cooled cows compared to non-cooled cows. Additionally, estrous behavior lasted longer in cooled (16 hours) than non-cooled (11.5 hours) cows having low body condition scores (average 2.6). Others have demonstrated a 15% decrease in services per conception and a reduction in the number of cows culled for reproductive failure (19 vs 7.7%) in response to prepartum cooling (Wiersma and Armstrong, 1988). Dunlap and Vincent (1971) reported heifers exposed to heat stress the first 72 hours after artificial insemination did not conceive at all.

Postpartum production benefits of cooling dry cows may be dependent on the length of the cooling period. Initial research in this area involved shade as the cooling method. While adequate shade is recommended for the far off dry cow (first 4 to 6 weeks of the dry period), recent work suggests that more extensive cooling systems may be justified for close-up dry cows. Much of the immune and endocrine responses reported with transition cows may be applicable to other immune-compromised groups, such as high-risk, mastitis, and sick pens.

Cooling should be provided for all cows housed in the special needs area. Low-pressure sprinklers or soakers should be placed on the feed lines. Mechanical ventilation or fans should be provided both on the feed lines and the housing area. The sprinklers should provide .03 gallons of water per square foot of wetted area per cycle. A common cycle would be 3 minutes on and 12 off. Typically 6 to 8 feet is wetted behind the feed lines (J. Harner et al., 1999). Fans should be placed on the feed lines and the cow housing areas to provide 800 to 1000 cfm per cow. Typically, a single row of fans over the feed lines and a single row of fans over the freestalls will accomplish the desired airflow. Thirty-six inch fans should be spaced a maximum of every 30 feet and 48-inch fans should be spaced every 40 feet. Fans over loose housing should be placed in banks with fans 10 feet on center with the banks of fans being spaced according to the diameter of the fans being used (J. Harner et al., 1999 and M. Brouk et al., 1999).

Dairy Layout

One of the issues with special needs facilities is where these facilities will be located on the dairy. They will either be located near the milking parlor or at the back of the dairy. Locating these facilities near the milking parlor reduces walking distance to and from the milking parlor. It also allows employees who work in close proximity to the parlor to observe close-up cows. The advantage of locating these facilities at the back of the dairy allow for easy movement of far off dry cows, beef cows and cows that have been dried off to and from the special needs facilities. Locating these facilities away from the main parlor may necessitate the need for a hospital parlor. If the dairy has two main parlors in a head to head configuration, the special needs facilities can be split into two barns directly behind the parlors. Figure 2 includes a drawing of a 2,400 lactating cow dairy with special needs facilities incorporated. You will notice that the special needs facility require the space equivalent to three pens of healthy lactating cows. Figures 3 and 4 include detailed drawings of the freestall buildings that would include the special needs facility.

Special Needs Facilities

Economic Impact

Generally, special needs facilities require additional capital investments by the dairy producer. These investments must be recovered in the form of additional milk sales from reduced culling, better health, etc. Unfortunately, the economic impact of special needs facilities is very case specific and generalization can be dangerous. Our objective, here, is to estimate the approximate magnitude of the additional investments required, of the additional expenses incurred, and of the additional milk production required to cover such costs.

The following points are important for understanding our analysis:

1. Cash-flow issues are not considered. Thus, we assume that the dairy has access to additional capital and that additional cash reserves are in place to ensure cash coverage in the short and medium term.
2. All capitalization projects are assumed to be financed at an annual rate of 8% for 10 years. We make no differentiation on the source of such capital. Thus, any additional equity capital has an implicit 8% annual rate of return built into it.
3. Because cash-flow issues are not considered, it makes no difference from a profitability standpoint whether the annual capital cost is in the form of interest or depreciation. The depreciation used for tax purpose could be different depending on prior fiscal decisions, current tax liabilities, future tax expectations, and changes in tax laws. Tax implications could change cost figures significantly.
4. Repairs and maintenance as an annual cost percentage of initial capital cost was set at 2 percent for buildings and 5% for equipment.

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The additional capital investment assumed for each component of the special needs facilities are reported in Table 3 along with a percentage of the milking herd for which they should be designed. Depending on the specific conditions of a herd, there are two views that can be taken with regard to these investments. The first one is that with the exception of the free-stalls for close-up cows and heifers and the hospital parlor (if constructed), facilities would have to be secured for the different classes of cows whether these animals are housed separately from the milking herd or not. For example, mastitic and sick cows would require 48 stalls in the freestall barns if special facilities were not built. An alternate view looks at all special needs facilities as a single investment project. With this view, all special needs facilities are considered as additional investments. In this document, we will report results for both ends of this spectrum. Thus, additional capital for special needs facilities would range between $288,000 and $1,056,400 in a 2,400 milking cow dairy, or an additional $120 to $440 of capital investment per milking cow.

The costs of capital (building and equipment) expenses are reported in Table 3 both on a total annual basis and on a per cow per year basis. At the low end, facilities for close-up cows and close-up heifers incur an additional capital cost of $18 per milking cow per year. At the high end, these costs would amount to $66 per cow per year, including the cost of a small double-10 parlor to milk an average of 48 mastitic and sick cows and 24 cows with non-sellable milk. Table 3 also presents the bedding cost expected from these specialized facilities. These costs are based on bedding cost of $50/stall per year, and $0.75 per cow per day on a bedded pack. Total bedding costs in the special needs facilities amount to $17 per cow per year. This figure overestimate the real net cost because it assumes that any alternatives to dedicated special needs facilities would incur no bedding cost.

Total expenses for the special needs facilities are estimated at $23 per cow per year at the low end, and $83.25 per cow per year at the very high end.

Special needs facilities may result in additional operating costs or savings depending on the conditions. The efficiency of cleaning animal facilities may or may not be improved. Parlor efficiency would likely improve if a small parlor were built to handle cows with non-sellable milk. Assuming that additional cows with sellable milk can be milked through the large herd parlor(s). The dairy could theoretically milk an additional 100 to 200 cows through the large parlor without any additional fixed costs and little additional labor cost.

Assuming gross milk revenues of $12/cwt and net marginal revenues (Income minus variable costs) of $6/cwt, special needs facilities require, at the minimum, an additional 383 pounds of milk/cow per year to break-even or roughly 1 pound of milk/cow per day. Using the high estimate for costs, special needs facilities require an additional 2,770 pounds of milk/cow per year, or roughly 7.5 pounds/cow per day. Because, in general, a great proportion of the capital and bedding cost would be incurred regardless of whether separate special needs facilities are built, we think that a figure equivalent to 2 pounds of milk cow per day is a good benchmark for the situation where a small parlor is not included. Because large parlors are more capital and labor efficient than small parlors, new facilities should be designed where all cows are milked in one large milking center. The large milking parlor would be used to milk the 9 groups of healthy lactating cows and high risk sellable cows 3x per day in 6.5 hours per shift, allowing 1.5 hours per shift to milk sick cows, fresh cows non-sellable and to clean the parlor facilities. During the initial planning, allowances should be made to construct a hospital parlor in the future. This way, a dairy can increase by 5 to 10% the number of cows with sellable milk being milked in the large dairy parlor in the future. Milking 3X herd size should be able to increase 10 to 15%.

Risk Management and Biosecurity

The special needs area provides a dairy an opportunity to manage risk through disease control measures (Wells, 2000). Manageable risks include disease (both animal and human), financial loss, marketability of milk and animals and potential liability. Animals housed in these facilities are particularly vulnerable to contracting new infections. This is especially true for fresh cows, which have suppressed immunity around the time of calving. The newborn calf is at risk to contract Johne's disease (*Mycobacterium paratuberculosis*). Cleanliness and daily maintenance of the calving area and the special needs facilities are critical. This area also provides an excellent opportunity to reduce the risk of antibiotic contamination of milk, as treated animals can be effectively isolated away from the lactating herd.

It is important to identify potential risks and develop a prioritized list and appropriate control measures. The manager needs to gather information and advice from the herd veterinarian and others to properly assess the exposure to these various diseases and develop a plan. Some of the pathogens generally regarded as high risk for dairy

Table 3. Additional capital investments for each component of the special needs facilities for 2,400 lactating cow dairy.

		Capital Expense[1]			Bedding Expenses[2]		Total Expenses[3]	
% of Herd	Category	Add. Capital	$/year	$/cow/ year	$/year	$/cow/ year	$/year	$/cow/ year
	Close-up cows and close-up heifers							
10	240 stalls @ $1200	$288,000	$43,200	$18.00	$12,000	$5.00	$55,200	$23.00
1	Calving area (120 × 40) @ $10/ft^2	48,000	7,200	3.00	6,500	2.70	13,700	5.70
1	Fresh cows — non sellable milk pen 24 stalls @ $1200	28,800	4,320	1.80	1,200	0.50	5,520	2.30
5	Fresh cows — sellable milk pens 120 stalls @ $1200	144,000	21,600	9.00	6,000	2.50	27,600	11.50
2	Mastitis and sick cows, non-sellable 48 stalls @ $1200	57,600	8,640	3.60	2,400	1.00	11,040	4.60
6	High-risk, sellable milk pen 144 stalls @ $1200	172,800	25,920	10.80	7,200	3.00	33,120	13.80
3	Hospital parlor							
	Double shell-building	80,000	12,000	5.00	—	—	12,000	5.00
	Equipment	140,000	21,000	8.75	—	—	21,000	8.75
1.5	Beef and calves shipping area 90 sq. ft/cow × $10/ft^2	32,400	4,860	2.00	5,000	2.10	9,860	4.10
	Treatment area 2500 sq. ft.: $25,000 Equipment: $25,000	50,000	7,500	3.10	—	—	7,500	3.10
	Calves area 800 ft^2: $8,000 Equipment: $1,800	9,800	1,470	0.60	1,200	0.50	2,670	1.10
	Office 200 ft^2 @ $25/ft^2	5,000	750	0.30	—	—	750	0.30
	Total	$1,056,400	$158,460	$65.95	$41,500	$17.30	$199.960	$83.25

[1]Capital expenses are based on 8% interest rate over 10 years and include depreciation, interest, taxes and insurance.
[2]Bedding expenses are based on $50 per/stall/year or $0.75 per cow/day on bedded pack.
[3]Total expenses are the sum of capital and bedding expanses.

herds include *Staphylcoccus aureus, Mycobacterium paratuberculosis* (Johne's disease), bovine viral diarrhea (BVD) and *Salmonella* species. In addition diseases such as mycoplasma, foot warts, *Chlamydia* and other pathogens for which there is not an effective vaccine could jeopardize individual cows as well as herd health. The highest risk for introduction of new disease into the herd comes from purchased cattle. Therefore, an effective program of pre-screening and isolation of new arrivals is an important key element of an effective biosecurity program. A location for accepting, processing and quarantining new arrivals should be located at least one-half mile from the closest animal facility. An additional risk exists with movement of animals in multiple site operations. Consideration should also be given to cattle movement, people movement, vehicles and equipment, feedstuffs, birds, rodents and wild ruminants, water and manure management.

An effective biosecurity program needs a written document. It must be clearly communicated to employees,

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consultants and visitors. Dairies should have appropriate signage to alert and remind people of the dairy's policies. The biosecurity plan should include a drawing depicting the traffic flow plan for all activities on the dairy. Access to the special needs facilities should be limited to only those personnel that are necessary to carry out the daily activities. This minimizes the transfer in or out of organic material or contaminated equipment that could spread infectious disease. Veterinarians, hoof trimmers, service persons, sales people and any other visitors to the dairy need to have easy access and a defined area where they are to perform their service to the dairy. This minimizes unnecessary traffic around the dairy. The capability to disinfect equipment should be provided in close proximity to working areas. Professional, delivery and service activities as well as sales personnel need to be aware of the dairy's policy on disease containment. Equipment and vehicles should be clean and/or disinfected. Clothing should also be clean and footwear should be of the type that can easily be disinfected. In some cases, on-site disposable coveralls and shoe covers may be provided.

Vehicles entering the dairy to deliver new arrivals should be afforded an entry point that allows bypass of the majority of the dairy and easy access to the isolation/quarantine area. Vehicles arriving to remove dead or cull animals should have a designated location where easy loading is available and away from the special needs area. This area could also double as a location where the herd veterinarian could perform post mortem examinations on dead animals. A provision for cleaning and disinfection should be considered. After removal of the carcass and rinsing of the area, a final disinfection should occur. Examples of disinfectant solutions include chlorhexidine diacetate (Nolvasan®-S), sodium hypochlorite (bleach), quaternary ammonium chloride (Spectrosol®) and quaternary ammoniums with bis-n-tributylin oxide (Roccal®-D Plus).

REFERENCES

Bickert, W.G. 2000. Restraint and treatment facilities and equipment. NRAES-129: Proceedings of Dairy Housing and Equipment Systems: Managing and Planning for Profitability. Northeast Regional Agricultural Engineering Service. Ithica, NY.

Bickert, W.G. 1998. Sorting, handling and restraining lactating cows for treatment and other purposes. Proceedings of Fourth International Dairy Housing Conference. American Society of Agricultural Engineers, St. Joseph. MI.

Brouk, M.J., J.F. Smith, and J.P. Harner, III. 2000. Freestall barn design and cooling systems. Heart of America Dairy Management Conference, St. Joseph, MO. pp. 87-94.

Collier, R.J., R.M. Eley, A.K. Sharma, R.M. Pereira, and D.E. Buffington. 1981. Shade management in subtropical environment for milk yield and composition in Holstein and Jersey cows. J. Dairy Sci. 62:844.

Collier, R.J., S.G. Doelger, H.H. Head, W.W. Thatcher, and C.J. Wilcox. 1982. Effect of heat stress during pregnancy on maternal hormone concentrations, calf birth weight, and postpartum milk yield of Holstein cows. J. Anim. Sci. 54:309.

Curtis, C.R., H.N. Erb, C.J. Sniffen, R.D. Smith, and D.S. Kronfeld. 1985. Path analysis of dry period nutrition, postpartum metabolic and reproductive disorders, and mastitis in Holstein Cows. J. Dairy Sci. 68:2347-2360.

Hardin, D.K., R.F. Randle and J.M. Zulovich. 1994. Creating a palpation workstation to enhance reproductive herd health. Proceedings of Third International Dairy Housing Conference: Dairy Systems for the 21s Century. American Society of Agricultural Engineers. St. Joseph. MI.

Harner, J.P. III, J.P. Murphy, M.J. Brouk, and J.F. Smith. 2000. Fan selection and maintenance. Heart of America Dairy Management Conference, St. Joseph, MO. pp.32-36.

Harner, J.P. III, J.F. Smith, M. Brouk, and J.P. Murphy. 1999. Sprinkler systems for cooling dairy cows at a feed line. MF-2401. Cooperative Extension Service Publication. Manhattan, Kans.: Kansas State University.

Kammel, D.W. and K.A. Janni. 2000. Facility design for the transition cow. NRAES-129: Proceedings of Dairy Housing and Equipment Systems: Managing and Planning for Profitability. Northeast Regional Agricultural Engineering Service. Ithica, NY.

Kammel, D.W., S.L. Gunderson, T. Rehbein, and R.A. Thompson. 2000. Transition cow facilities: case studies. NRAES-129: Proceedings of Dairy Housing and Equipment Systems: Managing and Planning for Profitability. Northeast Regional Agricultural Engineering Service. Ithica, NY.

Moore, R.B., J.W. Fuquay, and W.J. Drapala. 1992. Effects of late gestation heat stress on postpartum milk production and reproduction in dairy cattle. J. Dairy Sci. 75:1877-1882.

Nocek, J.E. 1997. Feeding management of the postpartum cow. *In: Mid-South Ruminant Nutrition Conference Proceedings*, ed. E.R. Jordan. pp. 54-61.

Stokes, S.R. and J. Pope. 1997. The response to Korral Kool Systems on dairy cow performance in Central Texas. *In: Balanced Dairying*, ed. E.R. Jordan. Vol. 20, No. 4.

Stone, B. 2000. Defining and managing special cows. NRAES-129: Proceedings of Dairy Housing and Equipment Systems: Managing and Planning for Profitability. Northeast Regional Agricultural Engineering Service. Ithica, NY.

Veenhuizen, M.A. and R.E. Graves 1994. Handling and treatment facilities for large dairies. Proceedings of Third International Dairy Housing Conference: Dairy Systems for the 21s Century. American Society of Agricultural Engineers. St. Joseph. MI.

Wells, S.J. 2000. Biosecurity on Dairy Operations: Hazards and Risks. J. Dairy Sci. 83:2380-2386.

Wolfenson, D., I. Flamenbaum, and A. Berman. 1988. Hyperthermia and body energy store effects on estrous behavior, conception rate, and corpus luteum function in dairy cows. J. Dairy Sci. 71:3497-3504.

Wiersma, F. and D.V. Armstrong. 1988. Evaporative cooling dry cows for improved performance. Am. Soc. Ag. Eng. Int. Mtg. #88-4053.

Figure 1. Timeline to move close up and fresh cows through the special needs area.

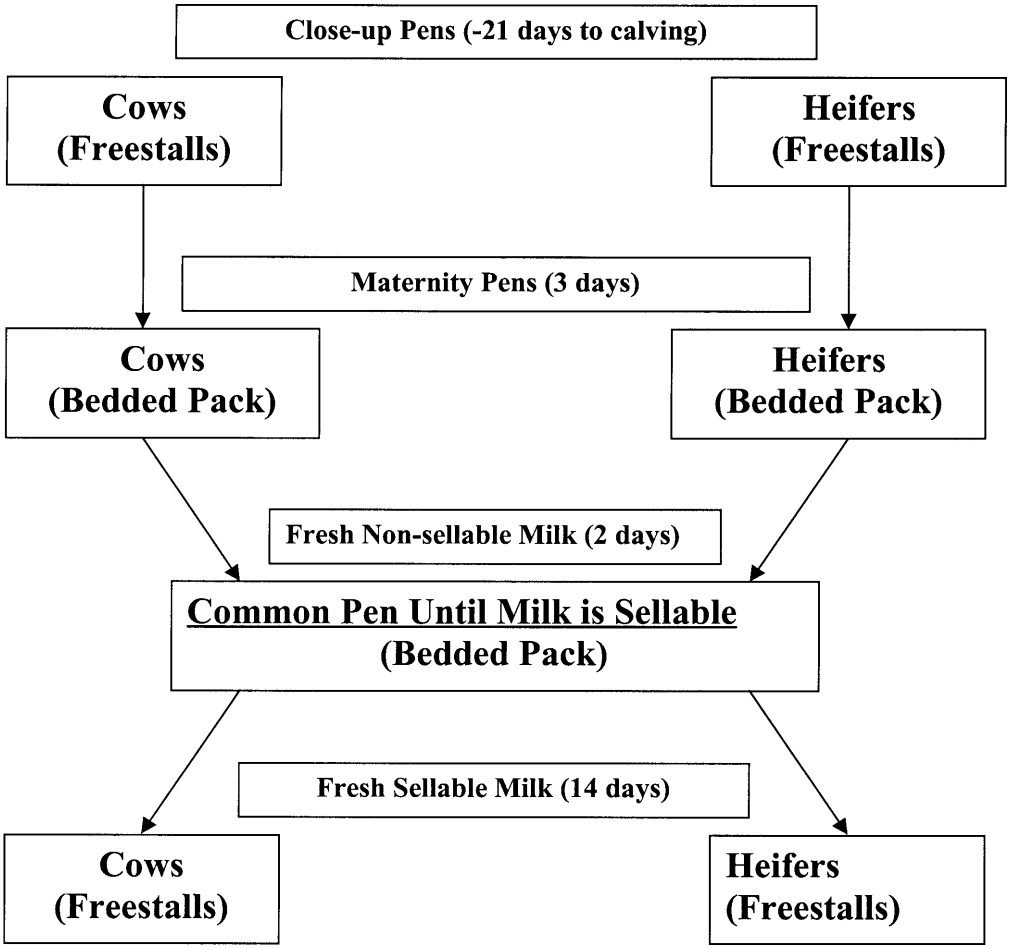
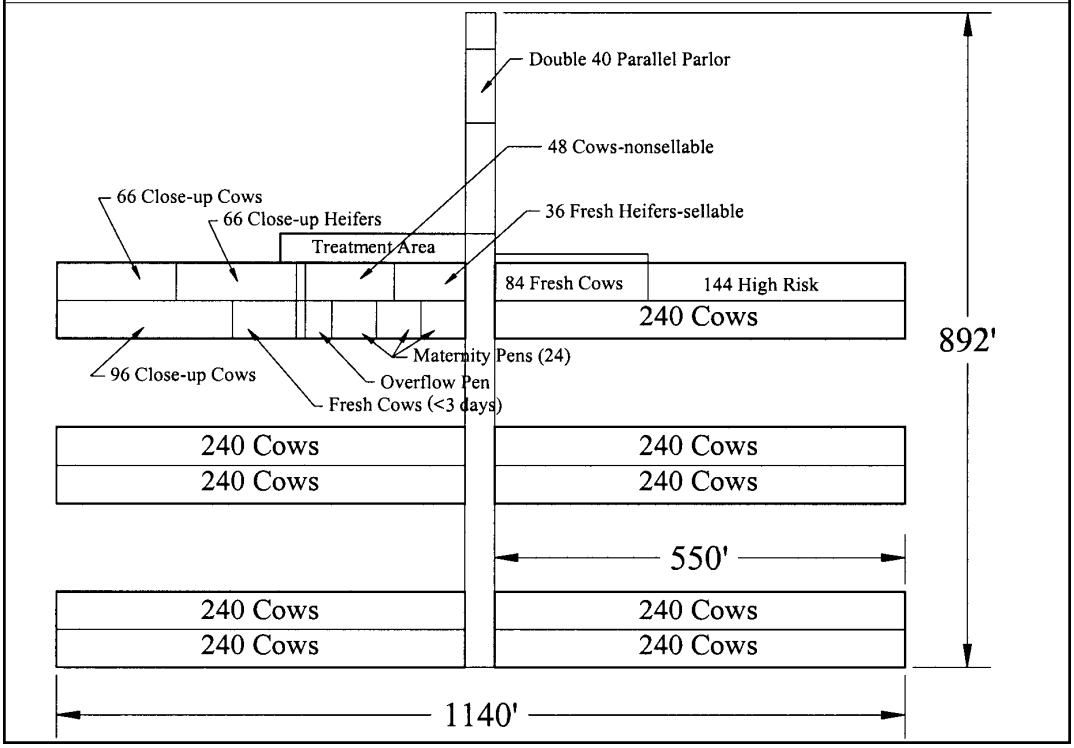


Figure 2. Layout for 2,400 Lactating Cow Dairy Facility Including Special Needs Facilities.



more →

Figure 3. Special Needs Facilities for Close-up, Maternity, and Non-sellable Cows

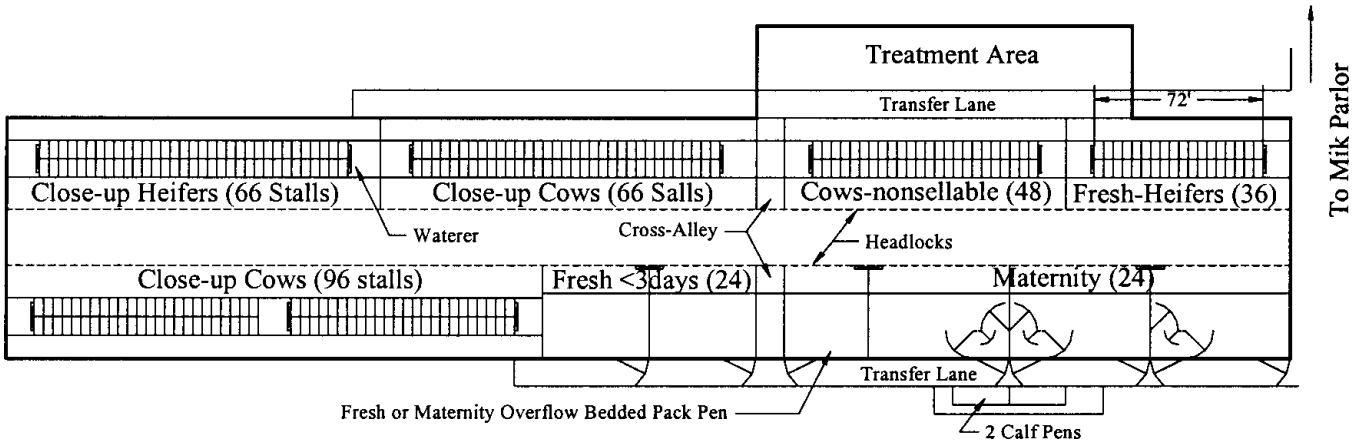


Figure 4. Special Needs Facilities for Fresh and High Risk Sellable Cows