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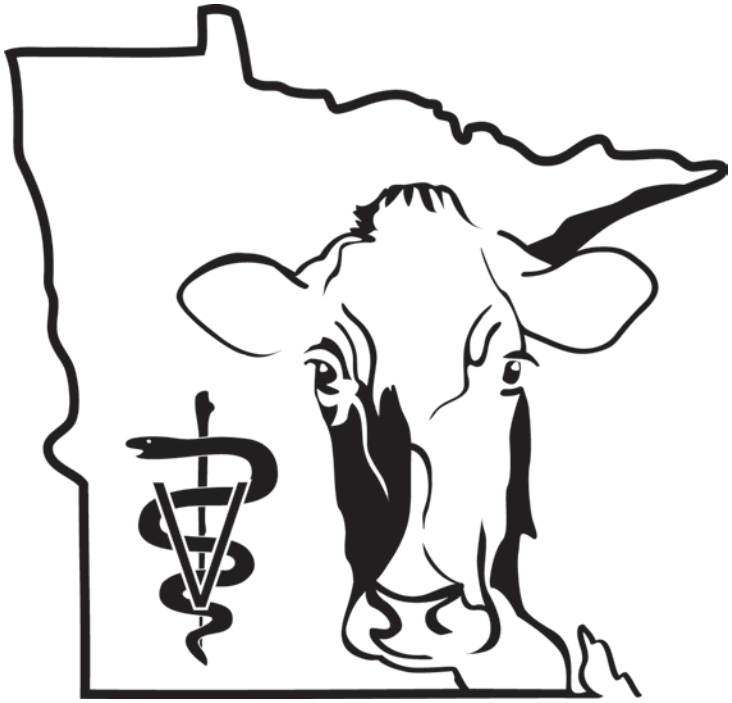

ST. PAUL, MINNESOTA
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PLANNING THE TRANSITION FROM STALL BARN TO FREE STALL HOUSING SYSTEMS

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The average Upper Midwest dairy producer milks 50 cows in a traditional stall barn. Changes in life style expectations, transfer of the farm to the next generation, and inefficient use of labor common in traditional stall barns has many producers interested in making the move to free stall and parlor systems. However, even the most profitable dairy producers (greater than 20,000 lb/cow/year, 80 to 90% equity) in the region are finding it difficult to expand the herd, build a free stall barn, new milking center, and modern waste handling system all at once.

The purpose of this paper is to discuss methods to make the desired changes in steps that will allow producer to make the transition from a stall barn to free stall housing system in the most profitable manner. Planning a transition is often more difficult than simply building a new dairy all at once. Key elements that must be considered are, site selection, definition of ultimate dairy size, flat parlor milking systems, and planning free stall barns around the cow management plan.

SITE SELECTION FACTORS

One of the most important decisions made in the planning of a new dairy facility is the selection of the building site. Evaluate the site with respect to factors related to natural ventilation, environmentally sound waste handling practices, and vehicle traffic arround the proposed milking and feed centers.

Site Selection Factors Related to Natural Ventilation

Naturally ventilated dairy buildings depend on the pressure differences across the building envelope created by the effects of thermal buoyancy (chimney effect) and wind to move air through the facility. Air movement induced by the chimney effects is not affected by the orientation of the builkding. However, the effectiveness of natural ventilation due to wind pressures is controlled by the orientation of the building and the position of the building relative to local obstructions. Since lactating dairy cows are subject to heat stress at temperatures of 75° F and above the orientation of the building wit respect to summer wind direction is critically important.

Orient new buildings to take advantage of prevailing summer wind. Based on weather statistics (MWPS-33) the prevailing summer wind direction in July is from the south, southeast, or southwest across the United States. In most of Minnesota, July summer wind direction has almost an equal probability of being from the southwest, south, or southeast. Therefore, the long axis of naturally ventilated buildings should run east and west. However, hills, mountains, or dense forrests can alter the prevailing wind direction in some locations.

Locate the building at least 50 ft from upright silos and clusters of trees, and 75 ft away from all other buildings. Separation distances of 100 ft or more are desirable for wide free stall barns. Locate the feeding system on the south side of the building if a drive-by feeding system is used or the building is

open to the south. If at all possible, locate the building such that no obstructions exist on the south side of the building. In many free stall systems the milking center should be located on the north side of the building do avoid wind shadows in parts of the animal housing area in the summer.

Site Selection Factors Related to Waste Management

The methods used and costs to collect, transfer, and store manure and other wastewater (i.e. milking center wastewater or flush water) will depend on several factors related to the soil-type and geology of the site. The odor nuisance potential for the farm residence and neighbors must also be evaluated. Once the site is selected, the manure and wastewater management system must be constructed so as to protect the quality of surface and ground water, and to minimize the impact of odors.

Every prospective building site for animal housing or waste storage should be evaluated based on the following factors: distance from lakes; distance from rivers, streams, wet-lands; drainage ditches, tile inlets, or grassed waterways; soil type; soil depth to the seasonally-high water table; depth to bedrock; presence of fractured bedrock; and drainage patterns of the farmstead. The evaluation of these farmstead factors can be quite complicated. Therefore, it is best to contact a professional consulting engineer, the Soil Conservation Service (SCS), or your local Soil and Water Conservation District for design assistance. A professionally developed site evaluation and plan is required as part of the application for a Minnesota Pollution Control Agency (MPCA) Feedlot permit ***if an earthen storage basin is used or if the storage structure has a capacity of more than 500,000 gallons.*** However, most livestock producers can make a preliminary evaluation of a site themselves by finding answers to the following questions. The recommendations given are based on the *general* requirements of the MPCA. If the building site is outside of Minnesota evaluate the site based on the requirements given by the appropriate regulatory agency.

How close is the proposed building site to lakes, rivers, streams or wet-lands?
Locate all livestock buildings, feed storages, and manure storages at least 1,000 ft from any lake. If a creek, river, drainage ditch, or wet-land is on or near the site make sure all proposed buildings and manure storages are at least 300 ft away. Maintaining the proper separation distances from surface water, and collecting all polluted runoff from outside lots will minimize the effect of livestock manure and wastewater on the quality of surface water.

What is the depth to the seasonally-high water table and bedrock?
The MPCA requires that the depth of the water table at the proposed site for a waste storage unit be determined by soil borings. However, a preliminary estimate can be obtained from the soil map of the farmstead. The SCS or ASCS office has a book of soil maps for the county. Use these books to "get an idea" of the depth to the water table and bedrock for the proposed site. Based on MPCA requirements the bottom of a waste storage should be 2 feet above the seasonally-high water table and 5 feet above ***normal*** bedrock if the soil is heavy. If the proposed site has fractured bedrock or very sandy soil then the depth to bedrock should be at least 10 feet. The Karst region of Minnesota (parts of Winona, Fillmore, Olmsted, Wabasha, Houston, Dakota, Washington, Hennepin and Goodhue Counties) is characterized by shallow, fractured bedrock. In the Karst region of the state, below-ground storages may be required to be concrete-lined or above-ground storage may be the only option. However, specific site requirements may vary, because soil type and bedrock characteristics vary greatly in the Karst regions of the state.

What type of soil is at the building site?

The type of soil can have a significant impact on the cost of constructing an earthen basin to store manure and wastewater. The costs of some common types of manure storage structures are compared in Table 1. If the soil is sandy, an earthen basin must be lined with a clay-type soil, concrete, or a heavy plastic liner. If the clay must be transported a significant distance the cost of constructing an earthen basin will be about 25% more than if suitable clay is available on the farmstead. A plastic or concrete liner may be comparable in cost to a clay-lined basin if the clay must be hauled a large distance. If the proposed building site has sandy soil and extremely shallow fractured bedrock then above-ground storage may be required. Above-ground storage typically cost twice as much as a lined earthen basin.

Table 1. Comparison of Costs for Manure Storages
(source: Minnesota State Office of the SCS, 1993)

Type of Storage Structure	**Approximate Cost Per 1,000 Gallons of Storage Capacity [a]**
	($/1,000 gal)
Unlined Earthen Basin	36
Clay-Lined Earthen Basin Using Clay Available on Site	70
Clay-Lines Earthen Basin Using Clay From an Off-Farm Borrow Site (varries with haul distance)	88
Earthen Basin Lined With a Plastic Liner (Geosynthetic Membrane)	76
Earthen Basin Lined With Concrete	88
Above-Ground Tank Constructed With Precast Concrete	141
Round, Above-Ground Tank Constructed of Poured in Place Concete	163
Above-Ground, Glass-lined tank	198

[a] Cost estimates based on 500,000 gal storage capacity. Cost per 1,000 gal will decrease significantly for larger storages.

What cropland will be used to utilize manure nutrients?

Application of livestock manure and wastewater to cropland helps to build and maintain soil fertility, improve soil tilth, and increases water holding capacity. Develop a land application plan early in the planning process of a new livestock production unit or waste storage unit. If sufficient cropland is not available close to the livestock production unit then it may limit the size of the unit, or greatly reduce the waste handling and land application options. For example, if the only cropland that is available for manure application is 10 miles away from the waste storage then towed hose injection can not be used, and the cost of hauling liquid manure will be high.

The amount of land that is required per cow or heifer will depend on: (1) the amount of N, P, and K in the manure and/or wastewater, (2) the amount of N lost in the handling and land application processes, (3) the amount of N, P, and K in the soil, (4) the amount of N, P, and K required by the crops, and (5) government regulations. The required manure application rate varies greatly depending on the methods used to handle and land apply manure. As a result, the land requirement based on applications of 100

to 120 lb of N per acre can vary from 0.55 to 1.15 acres per cow (Floren and Lazarus, 1994, MWPS-7). The current rule in Minnesota prohibits the application of manure at rates exceeding the nutrient requirements of the crop. At the present, this rule has only been applied to nitrogen (N). However, in the future it is likely that the rule will be applied to phosphorous (P) as well. As a consequence the land requirements can be 1.7 acres per cow or more based on 40 lb of P per acre (Floren and Lazarus, 1994). On the average, the manure from two heifers (all ages) is equal to one cow.

In the past, producers and dairy advisors have relied on rules of thumb to ***make the final decisions*** concerning land application of manure. However, rules of thumb are no longer sufficient for ***decision making in this area.*** Rules of thumb or "text book" examples are only valuable in that they demonstrate the principles, advantages, and impacts of land application techniques. They can also be used to indicate ***problem areas or limitations in the initial planning stage.*** The actual number of acres needed for a particular dairy ***must be calculated based on individual farm data .***

The basic guidelines for the development of a manure application plan are: (1) test the soil in each field to establish initial soil fertility (a value from a handbook is often used the *first* year or in the planning process), (2) test a sample from the manure storage after agitation to determine nutrient content (N,P,K), (3) calculate the manure application rate based on soil and manure test data, and realistic yield goals for a particular crop, (4) calculate the number of acres of cropland required to utilize manure nutrients, and (5) calibrate the manure spreading equipment to insure that the manure is being spread at the calculated rate. The following Minnesota Extension Service publications are recommended to assist in developing manure application plans for dairies.

Self Assessment Worksheets for Manure Management Plans (AG-FO-5883-C)
Fertilizing Cropland with Dairy Manure (AG-FO-5880-C)

Manure application planning software is also available through the Minnesota Extension Service.

Separation Distances Related to Sanitation

Allow at least 100 ft between a water supply and the location of a waste storage. Locate manure storages at least 50 ft from the milking center. Check with your local milk and health authorities for any additional spacing requirements.

Site Selection Factors Related to Odor Control

The importance of odor control will vary depending on the population density of the proposed building site. If the farmstead is isolated the impact of odors on the farm residence will be the primary concern. The factors that should be considered when selecting a site for livestock buildings and manure storages are: direction of prevailing winds, distance to neighbors and the farm residence, and topography.

Prevailing Wind Direction
Locate all buildings and waste storages so that prevailing winds do not carry odors towards the farm residence or neighbors. Slurry and liquid manure storages give off the most odor during the early spring, and during agitation and pumping. In the early spring, waste storage ponds turn over as the temperature increases and exposes foul smelling materials to the air. The turn over takes about 3 days, but can be shortened by mechanical agitation. In Minnesota, the prevailing wind direction is from the northwest in the winter and early spring, and from the south or southwest in the summer. As a result, the best location for animal housing and waste storage units would be to the east of the farm residence

in most situations. However, the presence of hills can alter the direction of the prevailing winds for a particular farmstead.

Separation Distance

The ideal separation distance between a livestock facility and the nearest neighbor to avoid an odor nuisance is highly variable and somewhat subjective. A minimum separation distance of a quarter mile has been used and provides some protection against odor problems. However, the topography of the area can also have an effect of the separation distance due to a condition called ***air drainage.*** During calm summer evenings the air near the ground begins to cool and drifts down-slope since cool air is heavier than warm air. If a livestock building or waste storage is located uphill from a town or cluster of houses the cool air will flow past the livestock facility, pick up unpleasant odors, and create a nuisance around dwellings in its path. As a result, it is best to choose a site that is not up-slope from the residences of neighbors. Large separation distances of 1 to 3 miles can help to dilute the strength of odors if the air drainage condition can not be avoided. On flat farmsteads, prevailing wind direction is typically the most important factor to consider.

Farmstead Visibility and Condition

Unfortunately many people smell with their "eyes". Providing a natural or artificial barrier between facilities and the public eye can reduce the localized environmental impact of your livestock operation, especially when it comes to odors. Consider planting several rows of trees or shrubs, building a soil berm or even a high windbreak fence between barns and manure storages and a public road. Natural and artificial barrier can also help to filter and disperse odors coming from facilities and manure storages. Another public perception is that if an operation looks bad it also smells bad. Keep facilities well maintained; grass should be mowed regularly and equipment (especially manure spreaders and surrey tankers / pumps) stored. Locating livestock facilities and waste storages away from the public view and maintaining a "tidy" farmstead will draw less attention to your site and improve the image of the entire operation.

Selection Factors Related to Access by Equipment and Trucks

Make sure that drive ways and lanes can be included that will accommodate milk trucks, feed trucks, and visitors. Construct well drained gravel drives that allow all-weather access. Well laid out and maintained lanes are more functional and are more attractive to the public.

DETERMINATION OF DAIRY SIZE

Determination of the eventual size of a dairy on a given farm is an important, but often over looked step in the planning of a transition from a traditional stall barn to a free stall housing system. Many times a producer, or even the veterinarian, will make a statement like "we plan to expand to 100 cows now but may deside to milk 500 cows one day". Determination of a realistic long term goal will allow the family to do a better job of planning the first step in the transition. That is to make the first step large enough to be profitable, and to make sure that any new facilities will fit into the next step in the expansion.

In most situations the ultimate size of the dairy will be determined by the following factors: (1) land base available on site or in the area for land application of manure, (2) availability of labor, (3) people and business management skills of the owner, and (4) income goals of the owner. In some parts of Minnesota and the Midwest manure will be applied on the dairy producers farm as well as on cropland of neighbors, and as a result land base will not be the liniting factor. In areas where a strong tradition

of crop production does not exist and the rural population is low, such as northeast Minnesota or northern Wisconsin, utilization of manure nutrients and availability may be the limiting factors. In other cases the dairy producer *knows* that his or her people and business management skills are not sufficient to manage a 300 to 500 cow dairy or they simply do not want that large of a dairy. As a result, the initial plans may need to be for a smaller size dairy that matches the confidence level of the producer. In the process of learning to manage the smaller dairy the producer may be incouraged to expand in the future.

Cows Per Worker

The number of cows that can be managed well per full-time worker (or full-time equivalent, FTE) is one of the key variables in selecting the ultimate herd size and the first step in the transition. The number of cows per FTE is also one of the measures of overall labor efficiency on a dairy farm. Increasing the number of cows per worker is the primary goal of any transition strategy, and is directly linked to profitability. Most stall barn herds in the Midwest require 30 to 40 cows per worker. In free stall and parlor systems the number of cows per FTE can range from 35 to 75 with 50 being about average. In well designed free stall and parlor systems (flat or pitted parlors) 60 cows per worker is an attainable goal. In order to develop a dairy housing system that will achieve 60 cows per worker, or more, labor must be used efficiently in the following areas: (1) milking cows,(2) feeding cows, (3) treatment of cows (including reproduction work),(4) handling and land application of manure, and (5) heifer raising. The milking and feeding tasks are the most time consuming on a dairy farm and as a result they receive the primary emphasis in planning a transition strategy. However, include in the plan locations for cold and mild weather maternity areas, treatment facilities, heated areas for surgery, and housing for heifers (or have them contract raised).

Estimates of Labor and Land Base Requirements for Dairies of Various Sizes

As stated previously, labor and manure management are two of the factors that must be considered when selecting dairy size. *General* recommendations for land base and number of full-time workers are given in Table 2. These values are intended as *only a starting point* for planning a transition from a stall barn to a free stall housing system. ***Other farm dependent factors and personal preferences must be included to define these parameters for a particular situation.***

MILKING SYSTEM - A KEY TO INCREASING COWS PER WORKER

During the transition from a stall barn to a free stall housing system the milking rate must be increased to increase the number of cows that can be managed well per worker. The the typical stall barn one worker uses three unautomated milking machines and milks 20 to 25 cows per hour. The primary goal is to double the milking rate. That is increase the milking rate to 40 to 50 cows per person per hour. If the milking rate is not improved profitability will suffer since labor must be added at about the same rate as cows.

Setting a goal of increasing the cows per worker rules out the possibility of using a simple switch system where one group of cows is housed in the stall barn and the other is kept in a free stall or loose housing barn. In most switch systems the milking rate falls to 12 to 17 cows per person per hour. Switch systems significantly increase the labor requirements for milking as well as feeding. Typically cow management suffers in switch system, the dairy producer becomes discouraged, profitability suffers, and burnout is inevitable.

Table 2. Estimates of Labor and Land Base Requirements for Dairy Farms.
FTE = Full-time Equivalent based on 8 hours / day
The number of actual workers will often be greater than value indicated since chores must be done 7 days a week.

NUMBER OF COWS (including dry cows)	NUMBER OF WORKERS (FTE)	APPROXIMATE LAND BASE NEEDED FOR MANURE APPLICATION (acres)	
		BASED ON N	BASED ON P
60 -80	Single Family, 1 - 1.6	54 - 72	102 - 136
100	1.67 -2.0	90	170
120	2.0 - 2.4	108	204
150	2.5 - 3.0	135	255
300	5.0 - 6.0	270	510
500	8.3 - 10.0	450	850
1000	16.7 - 20.0	900	1,700
TO DETERMINE ADDITIONAL LABOR NEEDED FOR HEIFERS MULTIPLY FTE BY 1.17		TO DETERMINE ADDITIONAL LAND BASE NEEDED FOR HEIFERS MULTIPLY ACRES BY 1.5	

Land application values are for corn and are based on MWPS-7, and Floren and Lazarus (1994). The above values are based only on handbook values. **Calculations must be made based on the crop rotation, yields, and manure and soil tests for a particular farm due to extreme farm-to-farm variability. In many cases the land base requirement will be greater than indicated.**

Pitted Parlors

Automated herringbone, parrallel, and side opening parlors can increase the milking rate or throughput rate to 40 to 99 cows per worker as indicated in Table 3. Obviously pitted parlors satisfy the need to double the milking rate as compared to stall barn milking systems, and greatly reduce the physical labor requirements. However, many dairy producers find the expense of a parlor prohibative during the beginning of a transition from a stall barn to free stall system. The costs of a new herringbone or parrallel milking center can vary from $10,000 to $15,000 per milking stall with most falling in the range of $12,000 to $13,250 per stall. Automated side opening milking centers range from $16,000 to $20,000 per stall.

Table 3. Steady-State Throughput Rates (cows per hour, cph) of Common Pitted Parlors Assumptions: (1) automatic detachers, (2) power entry gates, (3) crowd gates, (4) automatic sequencing on side opening parlors, and (5) one operator.

NUMBER OF STALLS PER SIDE	HERRINGBONE	PARRALLEL	SIDE OPENING
3	NR	NR	45 - 55
4	40 - 45	40 - 45	60 - 70
5	50 - 55	50 -55	72 - 80
6	55 - 60	55 - 60	NR
8	65 - 72	67 - 74	NR
10	75 - 80 [a]	77 - 82	NR
12	90 - 96 [a]	93 - 99	NR

[a] Includes rapid exit.,
NR = Not Recommended

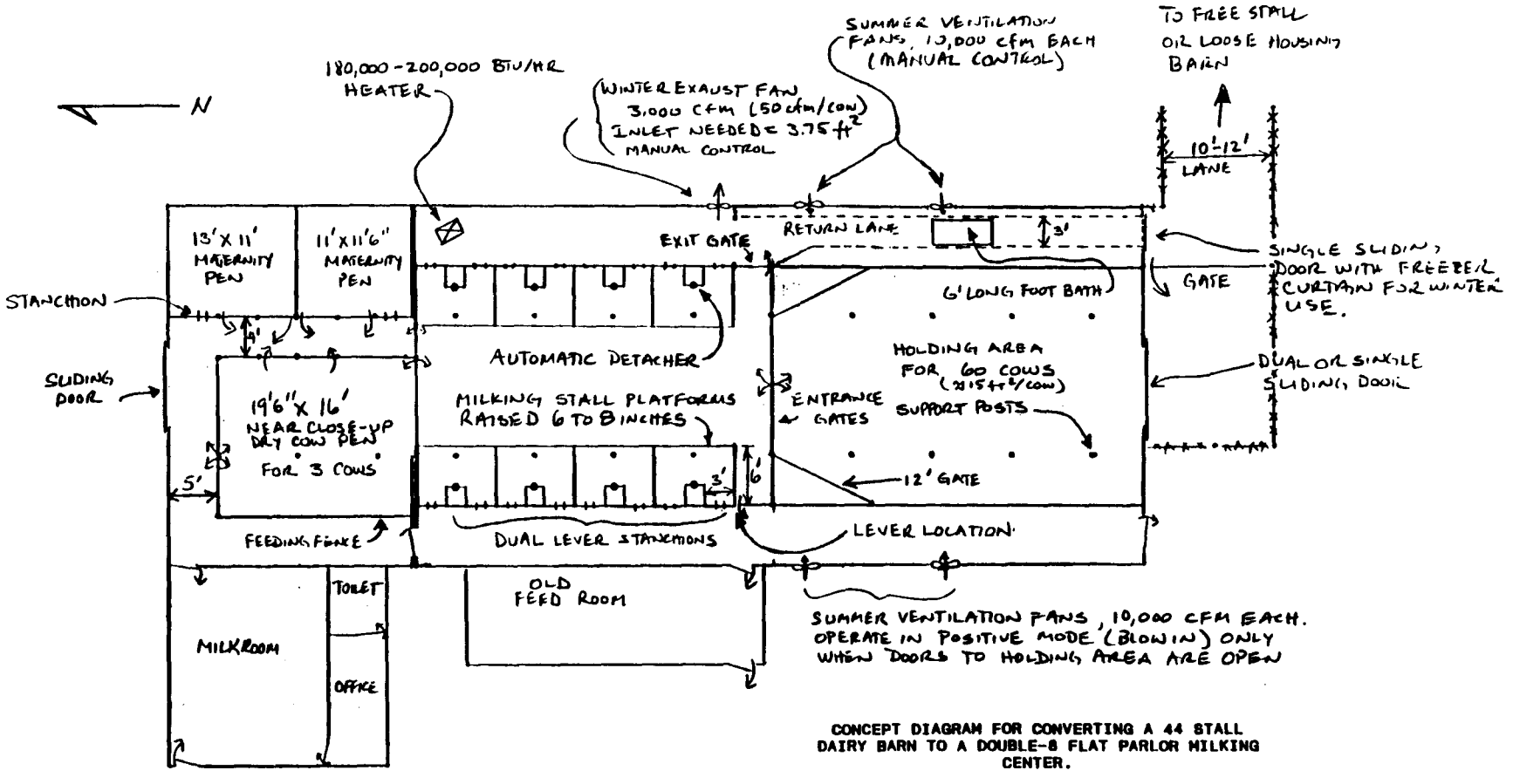
Flat Parlors

Flat parlors can be used to increase the milking rate at much less cost than a pitted parlor - often at 10 to 20% of a new pitted parlor. Most often the flat parlor is constructed by renovating the existing stall barn into a milking area, a holding area, return lanes, and possibly maternity or treatment areas. The concepts used to convert a stall barn to a double-8 flat parlor milking center are shown for a 44 stall dairy barn in Figure 1. The ***required*** elements of a flat parlor are: (1) a well defined milking area with 5 to 8 milking machines per person with automatic detachers, (2) a holding area sized to provide about 15 ft^2 per cow, (3) simple but effective entrance and exit gates, (4) dual lever stanchions to allow cows to be handled in groups or individually, (5) a return lane, (6) an all-weather lane that leads to the cow housing area, (7) heat, and (8) ventilation. A double-8 is not the only size of flat parlor that can be used. The throughput rates of the recommended range of flat parlor sizes is shown in Table 4. These values were developed based on field observations in Minnesota.

Table 4. Expected Throughput Rates (cows per hour) of Flat Parlors With Automatic Detachers.

FLAT PARLOR SIZE	1 OPERATOR	2 OPERATORS
SINGLE -10	30- 35	NR
SINGLE - 12	35 - 40	NR
DOUBLE-6	35-40	50
DOUBLE-8	45 - 50	55 - 60
DOUBLE-10	50 - 55	70 - 75
DOUBLE-12		75 - 80
DOUBLE-16		85-100

NR = Not Recommended



CONCEPT DIAGRAM FOR CONVERTING A 44 STALL DAIRY BARN TO A DOUBLE-8 FLAT PARLOR MILKING CENTER.

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EXPECTED THROUGHPUT WITH ONE PERSON IN THE MILKING AREA IS 45 TO 50 COWS PER HOUR.

Figure 1

Dual Lever Stanchions

Dual lever stanchions are recommended as the stall fronts to facilitate handling cows in groups or individually. The recommended dual lever stanchions will allow: (1) every other cow to be released or restrained as a group, and (2) an individual cow to be released or restrained independently. These features allow the operator to: (1) isolate a cow for transfer to a treatment pen off the end of the milking area, or (2) continue milking around a slow cow. Many of the lever stanchions that can be purchased used or new have a group lever on the end of the row of stanchions and single levers above each stanchion. The second group lever typically must be added if stanchions are purchased used. Dual lever stanchions are one of the key elements to provide efficient cow flow in flat parlors. Locate the levers on the entrance side of the parlor (Figure 1).

Remove Gutters

Dairy cows have poor depth perception and are fearful of open gutters and wholes. Consequently, the gutter behind the stalls interferes with cow flow in a flat parlor. Cows tend to jump across the gutter as they enter the stall, and back out of the stall at an angle striking the next cow. Fill in the gutters with concrete. Spread chopped bedding on the parlor floor, and clean the area with a skid-steer loader. Bedding can also be used in the holding area to facilitate cleaning.

Automatic Detachers

Automatic detachers are an essential part of the flat parlor concept. Cord or chain-type detachers are typically used. Both parlor and stall barn type detachers can be used in flat parlors. This disadvantage of stall barn detachers is that the entire detacher and milking machine must be carried into the milk room to be cleaned. If a parlor type detacher is used a third pipe is added to serve as the wash line to clean the detacher sensor in place. Milking machines should not be cleaned in the flat parlor. Wash and store them in the milk room. The expense of a clean in place system is typically not justified and the walls and ceiling of the stall barn may have to be upgraded to meet grade A requirements.

Automatic detachers function best if they are mounted as close to the udder as possible. If the detacher is too far from the udder then the machine will hit the floor when removed. A three-sided bracket (indicated in Figure 1) can be built to hold the detacher 3 ft away from the stall front towards the udder. The bracket will also provide protection for the milking equipment and a place to store supplies. Mount a single service paper towel dispenser at each detacher. A hanger for a teat dip cup or a teat dip spray hose can also be located at each milking station for convenience.

Automatic detachers increase the rate of milking by allowing one person to effectively use 6 to 8 machines. However, they also reduce labor requirements for the milking system. In a typical stall barn the operator performs 3 deep knee bends per cow. The automatic detacher eliminates 1 deep knee bend per cow. If the barn will have a flat floor after the gutters are filled in then adding a 6 to 8 inch high platform to the milking stalls is recommended. The raised platform will allow the operator to perform pre and post milking hygiene tasks by placing one foot on the platform, and bending at the knees and waist. The combined effect of the raised platform and the automatic detacher is to reduce the average number of deep knee bends per cow from 3 to 1. As a result, one person can milk 100 cows in a flat parlor with about the same number of deep knee bends as required to milk 33 cows in a conventional stall barn. A platform height of 10 inches would be more beneficial to the operator, but the effect on cow movement is not known at this time.

Milk Line Slope

In most stall barns a 2 inch diameter milk line is used and is sloped about 1 inch per ten feet of length (0.8%). In a flat parlor the slope of the milk line should be increased to about 2 inches per 10 ft

(1.7%) to allow 4 machines to be used per slope on two inch line (Mein et al., 1993). This will allow a producer to construct a double-8 flat parlor without investing in a 3 inch receiver. Also, the amount of wastewater that is generated from pipeline washing will be greatly reduced. Double-12 and 16 flat parlors will require either 4 slopes with 2 inch pipe (and two receivers) or 2 slopes of 2.5 inch pipe. Three inch pipe can be used, but generates additional wastewater. Mount the pipeline as low as practical to improve vacuum stability.

A double-8 flat parlor has been constructed in Minnesota using two inch pipe based on the above milk line slope recommendations. No milk flow oe cleaning problems have been observed.

Feeding in The Flat Parlor is Not Recommended

Providing feed and water in the flat parlor is not recommended. Feed may entice the cows to enter, but it may cause them to be slow to exit. Feeding in any parlor will also induce defecation and will require more labor for clean-up. It is not uncommon to provide a small amount of grain in the flat parlor during the initial training process. However, once the majority of the cows understand what is expected of them remove all feed. Cows will soon learn that fresh feed will be available in the housing area after milking and is enticement enough. As with any type of parlor, pitted or flat, cows with a poor disposition can not be tolerated.

Flat Parlor Operation

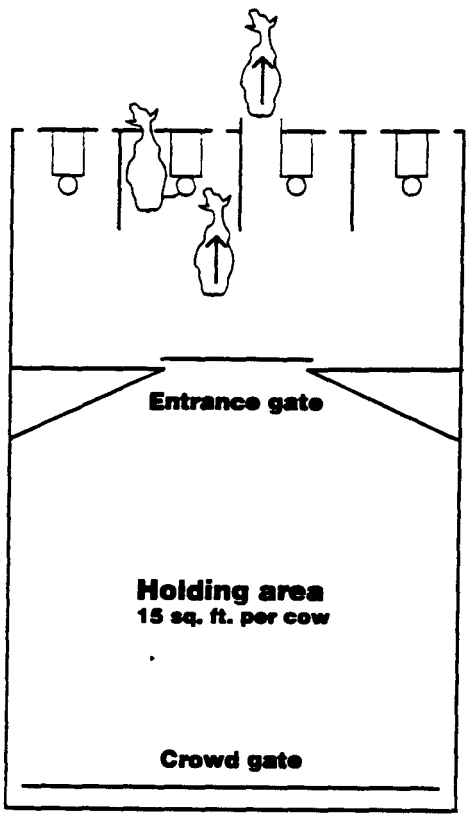
The most common type of flat parlor that is used in stall barn renovation is the walk-in, back-out type, shown in Figure 1. A single milking machine and automatic detacher is mounted between a pair of milking stalls. The *general* milking procedure is described below in the context of a double-8. Most producers modify this procedure somewhat based on personal preference.

(1) Milking is begun by opening the entrance gate and filling all of the milking stalls.
(2) The operator prepares the udders of every other cow on one side of the flat parlor and then attaches the milking machines.
(3) The same procedure is followed on the opposite side of the flat parlor - prepare every other cow and attach machines.
(4) Next the operator returns to the initial side and begins the udder preparation for the cows that will be milked next. By the time the udders of these four cows are prepared for milking the automatic detachers have removed the machines from the first four cows that were milked.
(5) The machines are attached to the cows in the adjacent stalls. The cows that have been milker are post-dipped and are let out of the stalls as a group using the appropriate lever and they exit through the return lane.
(6) The operator then prepares and milks the 4 cows that are waiting on the opposite side of the parlor.
(7) The cows that have been milked are post-dipped and exit the parlor.
(8) Empty stalls are loaded with cows from the holding pen, and the procedure continues until the group is milked.

Walk-Through Stalls

Walk-through stalls, Figure 2, can be used in flat parlors, but are typically more expensive to adapt to an existing barn than the walk-in, back-out stall. The number of cows that can be milked per person per hour is similar to walk-in,, back-out stalls (Reinemann et al., 1992). The primary difference is that cows are typically handled individually.

Figure 2 (Reinemann et al., 1992)



Typical walk-through stall arrangement

Flat Parlors in Head-to-Head Stall Barns

If the stalls in the barn face head-to-head then a single row of stalls are used for milking. The other side can be used for a treatment area, maternity area or the holding area. Common flat parlor configurations for one operator would be single 10, 12, or 16 , and would require 5, 6 or 8 units respectfully. If two people will typically milk cows consider a double 10, 12, or 16. Each person would operate half of the parlor independent of the other and may improve the labor efficiency. Depending on the size of the barn one or two holding pens can be used.

Flat Parlor Costs

The cost of renovating a stall barn to a flat parlor milking center varies greatly depending on the: amount of new milking equipment that must be purchased; capacity of the existing receiver, vacuum pump, and bulk tank; and the amount of remodeling that must be done to the building to establish the entrance, return lane, or holding area. Excluding bulk tank costs, a flat parlors cost range from $ 800 to $1,500 per milking stall. Several double-6 and double-8 flat parlors have been installed for $10,000 to $16,000. In most cases additional bulk tank capacity is required. The cost of bulk tanks can range from a few thousand dollars for used units to $25,000 or more for a new tank. In fact, the bulk tank is often the single greatest expense associated with a flat parlor.

Using Flat Parlors in New Buildings

Some dairy producers are not able to renovate their stall barn to a flat parlor and equity is not available to make the large scale expansion that is typically needed to afford a new pitted parlor. Common reasons that a producer may consider a building a new building for a flat parlor are: (1) the stall barn is too old to be used for anything; (2) the stall barn is in an unusable location; or (3) the stall barn has been destroyed by fire, flood, or tornado. Concept diagrams for a new single-10 and double-8 are shown in Figures 3 and 4. Both of these buildings allow the future installation of a herringbone or side opening parlor. Facilities for animal treatment are included to eliminate the need for self-locking stanchions in the free stall area.

The total cost of a new building and flat parlor will vary depending on the amount of milking equipment that can be used from the stall barn, holding area size, and number of treatment pens included in the new building. The cost of the insulated portion of the building and concrete will be about $12 per square foot. It was estimated that the costs of using a flat parlor in a new building can range from $50,000 to $70,000. However, such a building has not been built in Minnesota.

Comparison of Costs and Milking Shifts Between Herringbone and Flat Parlors

One of the most important questions to ask when considering the transition from a stall barn to a free stall and parlor system is does investment in a flat parlor make economic sense and how long will the milking shift be? In order to answer this question the milking shift, investment costs, and annual costs were estimated for new double 4, 6, 8, and 10 herringbone parlors for herd sizes from 80 to 600 cows. The same type of estimates were performed for a double-6 and flat parlor. Two cases were assumed for the flat parlor: (1) construction of a flat parlor in a renovated stall barn, and (2) construction of a flat parlor in a new building. The calculations for the herringbone parlors are given in Tables 5a through 5d. Flat parlor results are shown in Tables 6a and 6b.

Estimate of the Milking Shift

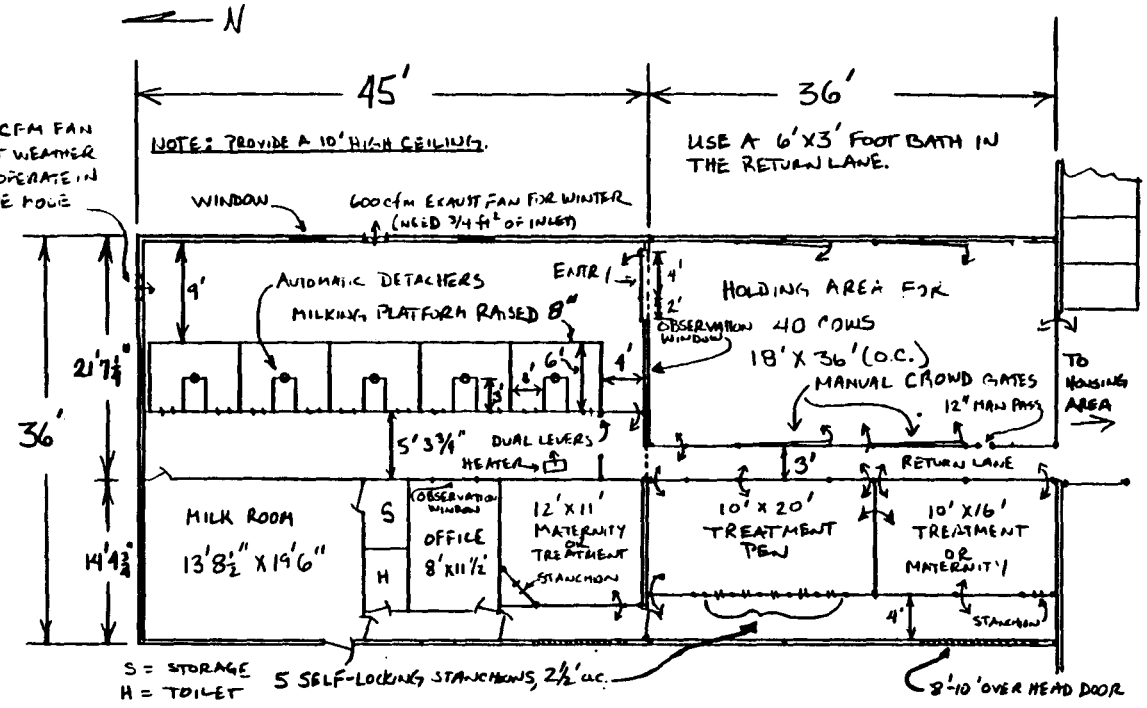
Estimates of the milking shifts for herringbone parlors were made based on the empirical relationships presented by Barry et al. (1992) using the range of steady-state throughput rates indicated in Table 3. Steady-state throughput (SST) is a measure of parlor performance that does not include the delays associated with group changes, slow cows, etc. It is primarily a measure of the capabilities of the equipment and the skill of the operator. Milking-time throughput (MTT) includes all delays but not the time for parlor set-up and clean-up. Barry et al. (1992) developed the following regression equation that relates steady-state throughput to milking time throughput for herringbone parlors ranging from double-4 to double-12 (the coefficient in Barry's equation was rounded off to the nearest tenth).

$$MTT = 0.9\ SST,\ r^2 = 0.96,\ n = 30 \text{ parlors} \quad (1)$$

Barry also determined that the average time required for set-up and clean-up for the 30 parlors in the study was 0.5 hours. Based on these results, the chore time required for a milking shift for herringbone parlors on farms that milk twice-a-day (2X) can be estimated by the following equation.

$$\text{Milking Shift} = 0.5 + (\text{No. of Cows Milked} / \text{MTT}) \quad (2)$$

The chore time for the flat parlors were calculated using the throughput values given in Table 4 with equation 2. The values in Table 4 correspond to MTT not SST.



HOLDING AREA NOTES:

A PERMANENT WASHABLE WALL IS LOCATED BETWEEN THE PARLOR ROOM AND THE NATURALLY VENTILATED HOLDING AREA. A 6 FT WIDE OVER HEAD DOOR IS USED FOR THE ENTRANCE. IT IS COMBINED WITH A 4 FT GATE. DURING WINTER, A PLASTIC STRIP FREEZER CURTAIN IS USED TO SEPARATE THE MILKING AREA AND THE HOLDING AREA. A SIMILAR TYPE OF DOOR AND FREEZER CURTAIN CAN BE USED ACROSS THE 3 FT WIDE EXIT TO THE RETURN LANE.

AN OBSERVATION WINDOW IN THE WALL BETWEEN THE HOLDING AREA AND RETURN LANE IS RECOMMENDED. COWS ENTER ANY TYPE OF PARLOR BETTER IF THEY CAN SEE INTO THE MILKING AREA.

TWO SETS OF MANUAL CROWD GATES AND A 12 INCH MAN PASS ARE PROVIDED IN THE HOLDING AREA. THESE GATES ALLOW THE OPERATOR TO REDUCE THE SIZE OF THE HOLDING AREA WHILE MILKING A GROUP, AND TO LOAD A SMALLER SECOND GROUP INTO THE HOLDING PEN WHILE COMPLETING THE MILKING OF THE FIRST GROUP.

PROVIDE AN 8 INCH RIDGE VENT AND ADJUSTABLE SIDE WALL CURTAINS. CURTAINS ARE CLOSED BY RAISING THEM WITH A MANUAL WINCH. INSULATE THE ROOF TO R-5 TO 10 IN A BIRD-PROOF MANNER. INSULATED CURTAINS CAN BE USED ON THE SIDE WALLS BUT ARE NOT REQUIRED. A PVC PIPE CAN BE RAISED WITH A CORD AND PULLEYS TO REDUCE THE SIZE OF THE RIDGE VENT DURING EXTREMELY COLD WEATHER.

THE HEAT FROM THE COWS IN THE HOLDING AREA AND A 180,000 TO 200,000 BTU/HR HEATER IN THE PARLOR ROOM (LOCATED NEAR THE END OF THE ROOM) WILL ALLOW THE OPERATOR TO WORK COMFORTABLY IN THE PARLOR IN THE WINTER.

MILKING SYSTEM NOTES:

A SINGLE-10 FLAT PARLOR (5 UNITS WITH AUTOMATIC DETACHERS) WILL PROVIDE A THROUGHPUT RATE OF ABOUT 35 COWS PER HOUR. THE CONCRETE MILKING PLATFORM IS RAISED 8 INCHES TO REDUCE THE NUMBER OF DEEP KNEE BENDS PER COW. THE RAISED PLATFORM USED WITH AUTOMATIC DETACHERS WILL GREATLY REDUCE THE LABOR AS COMPARED TO STALL BARN MILKING SYSTEMS.

USE DUAL LEVER STANCHIONS FOR THE MILKING STALL FRONTS. SELECT STANCHIONS THAT ALLOW: (1) EVERY OTHER COW TO BE RELEASED OR RESTRAINED AS A GROUP, AND (2) AN INDIVIDUAL COW TO BE RELEASED OR RESTRAINED INDEPENDENTLY. THESE FEATURES ARE NEEDED TO ALLOW THE OPERATOR TO (1) ISOLATE A COW FOR TRANSFER TO THE TREATMENT AREA OR (2) CONTINUE MILKING AROUND A SLOW COW.

A WALK-IN, BACK-OUT PARLOR IS SHOWN. HOWEVER, A WALK-THROUGH FLAT PARLOR COULD BE USED WITH THIS PLAN BUT AT MORE EXPENSE.

THE FLAT PARLOR ROOM SHOWN WILL ACCOMMODATE THE FOLLOWING PITTED PARLORS IN THE FUTURE: (1) DOUBLE-4 HERRINGBONE, (2) DOUBLE-3 SIDE OPENING, OR (3) A DOUBLE-6 HERRINGBONE. PART OF THE FLAT PARLOR ROOM (≈ 9 FT) CAN BE USED TO INCREASE THE HOLDING AREA CAPACITY TO 54 COWS.

TREATMENT NOTES:

SELF-LOCKING STANCHIONS ARE NOT REQUIRED IN THE HOUSING AREA. COWS THAT NEED TO BE TREATED OR BRED CAN BE MANUALLY SORTED TO THE TREATMENT AREA WHILE MILKING. THE TREATMENT AREA IS EQUIPPED WITH 5 SELF-LOCKING STANCHIONS FOR ANIMAL RESTRAINT. MAKE SURE THAT FEED IS AVAILABLE IF THE COWS WILL BE WAITING FOR THE VETERINARIAN.

A TREATMENT PEN IS PROVIDED IN THE WARM SECTION OF THE MILKING CENTER. THIS IS REQUIRED FOR VETERINARY TREATMENT OR PROBLEM CALVINGS DURING COLD WEATHER.

CONCEPT DIAGRAM FOR A SINGLE 10 FLAT PARLOR MILKING CENTER THAT CAN BE CONVERTED TO A PITTED PARLOR IN THE FUTURE

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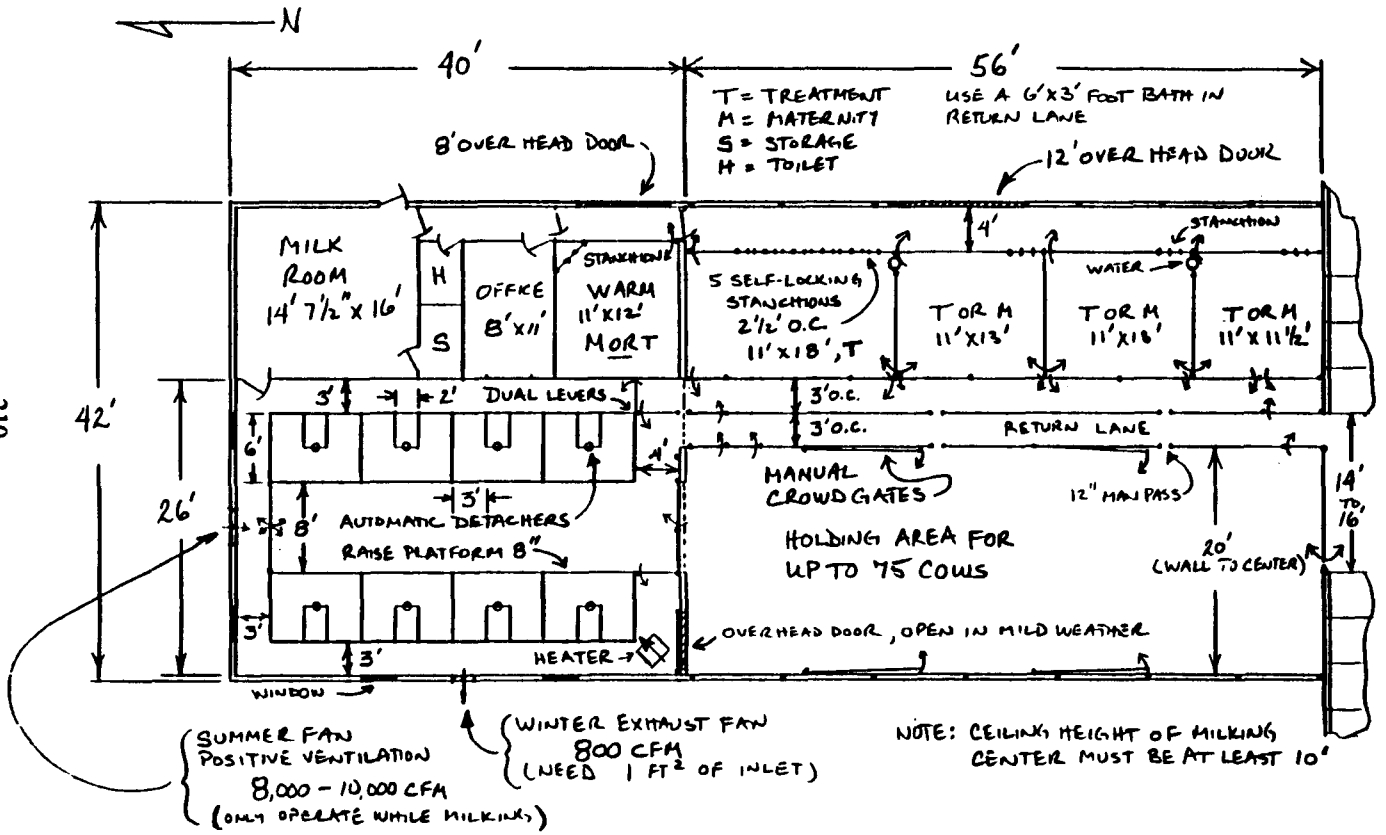
Figure 3



HOLDING AREA NOTES:

A PERMANENT WASHABLE WALL IS LOCATED BETWEEN THE PARLOR ROOM AND THE NATURALLY VENTILATED HOLDING AREA. OVER HEAD DOORS ARE USED FOR THE ENTRANCE AND EXIT. DURING WINTER, A PLASTIC STRIP FREEZER CURTAIN IS USED TO SEPARATE THE MILKING AREA AND THE HOLDING AREA.

PROVIDE AN 8 INCH RIDGE VENT AND ADJUSTABLE SIDE WALL CURTAINS. CURTAINS ARE CLOSED BY RAISING THEM WITH A MANUAL WINCH. INSULATE THE ROOF TO R-6 TO 10 IN A BIRD-PROOF MANNER. INSULATED CURTAINS CAN BE USED ON THE SIDE WALLS BUT ARE NOT REQUIRED. A PVC PIPE CAN BE RAISED WITH A CORD AND PULLEYS TO REDUCE THE SIZE OF THE RIDGE VENT DURING EXTREMELY COLD WEATHER.

THE HEAT FROM THE COWS IN THE HOLDING AREA AND A 180,000 TO 200,000 BTU/HR HEATER IN THE PARLOR ROOM (LOCATED NEAR THE END OF THE ROOM) WILL ALLOW THE OPERATOR TO WORK COMFORTABLY IN THE PARLOR IN THE WINTER.

TREATMENT NOTES:

SELF-LOCKING STANCHIONS ARE NOT REQUIRED IN THE HOUSING AREA. COWS THAT NEED TO BE TREATED OR BRED CAN BE MANUALLY SORTED TO THE TREATMENT AREA WHILE MILKING. THE TREATMENT AREA IS EQUIPPED WITH 5 SELF-LOCKING STANCHIONS FOR ANIMAL RESTRAINT. MAKE SURE THAT FEED IS AVAILABLE IF THE COWS WILL BE WAITING FOR THE VETERINARIAN.

A TREATMENT PEN IS PROVIDED IN THE WARM SECTION OF THE MILKING CENTER. THIS IS REQUIRED FOR VETERINARY TREATMENT OR PROBLEM CALVINGS DURING COLD WEATHER.

MILKING SYSTEM NOTES:

A DOUBLE-8 FLAT PARLOR (8 UNITS WITH AUTOMATIC DETACHERS) WILL PROVIDE A THROUGHPUT RATE OF 45 TO 50 COWS PER HOUR. THE CONCRETE MILKING PLATFORM IS RAISED 8 INCHES TO REDUCE THE NUMBER OF DEEP KNEE BENDS PER COW. THE RAISED PLATFORM USED WITH AUTOMATIC DETACHERS WILL GREATLY REDUCE THE LABOR AS COMPARED TO STALL BARN MILKING SYSTEMS.

USE DUAL LEVER STANCHIONS FOR THE MILKING STALL FRONTS. SELECT STANCHIONS THAT ALLOW: (1) EVERY OTHER COW TO BE RELEASED OR RESTRAINED AS A GROUP, AND (2) AN INDIVIDUAL COW TO BE RELEASED OR RESTRAINED INDEPENDENTLY. THESE FEATURES ARE NEEDED TO ALLOW THE OPERATOR TO (1) ISOLATE A COW FOR TRANSFER TO THE TREATMENT AREA OR (2) CONTINUE MILKING AROUND A SLOW COW.

CONCEPT DIAGRAM FOR A DOUBLE-8 FLAT PARLOR MILKING CENTER THAT CAN BE CONVERTED TO A DOUBLE-6 OR 8 HERRINGBONE IN THE FUTURE.

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Figure 4

The effect of three time-a-day milking (3X) on the milking shift is to increase the milking-time throughput rate by about 10%. Therefore, the milking shift for 3X was calculated for herringbone parlors using equation 2 with the steady-state value.

Estimation of Annual Costs

Calculation of the annual fixed costs was based on a publication by Bennett, et al. (1991) based on the following assumptions:

(1) 12% APR
(2) buildings depreciated over 15 years,
(3) equipment depreciated over 10 years with a 10% salvage value,
(4) taxes and insurance was 1.2% of the total cost,
(5) repair cost on buildings was 2% of purchase price if used less than 10 hours per day, 3% if used more than 10 hours per day, and
(6) repair costs on equipment was 4.5% of purchase price if used less than 10 hours / day, 7% if used more than 10 hours/day.

Labor costs were calculated as:

Labor Costs = [(average milking shift) x (No. of Milkings/day) x 365 x $8] / Total Herd Size. (3)

Total annual costs is the sum of the fixed and labor costs.

Table 5a. Estimated Milking Shifts and Costs For a Double-4 Herringbone Parlor
Assumptions:
Milking Center Cost = $100,000
Steady-State Throughput = 40 to 45 cows per hour
Milking Time Throughput = 36 to 40 cows per hour
Chore Time for Set-Up and Clean Up = 0.5 hour
Labor Costs Based on $8 per Hour.

TOTAL HERD SIZE	COWS MILKED PER DAY (88% in milk)	ESTIMATED MILKING SHIFT (hours)		INVESTMENT PER COW	ANNUAL FIXED COST PER COW	TOTAL ANNUAL COSTS PER COW	
		2X	3X			2X	3X
80	70	2.3 - 2.4	2.1 - 2.3	$1,250	$225	$397	$466
100	88	2.7 - 2.9	2.5 - 2.7	$1,000	$180	$344	$408
150	132	3.8 - 4.2	3.4 - 3.8	$667	$131	$287	$341
200	176	4.9 - 5.4	4.4 - 4.9	$500	$98	$248	$302
250	220	6.0 - 6.6	5.4 - 6.0	$400	$79	$226	$279

Table 5b. Estimated Milking Shifts and Costs For a Double-6 Herringbone Parlor

Assumptions:

Milking Center Cost = $145,000

Steady-State Throughput = 55 to 60 cows per hour

Milking Time Throughput = 50 to 55 cows per hour

Chore Time for Set-Up and Clean-Up = 0.5 hour

Labor Costs Based on $8 per Hour.

TOTAL HERD SIZE	COWS MILKED PER DAY (88% in milk)	ESTIMATED MILKING SHIFT (hours)		INVESTMENT PER COW	ANNUAL FIXED COST PER COW	TOTAL ANNUAL COSTS PER COW	
		2X	3X			2X	3X
150	132	2.9 - 3.1	2.7 - 2.9	$967	$173	$290	$337
200	176	3.7 - 4.0	3.4 - 3.7	$725	$130	$242	$285
250	220	4.5 - 4.9	4.2 - 4.5	$580	$113	$223	$265
300	264	5.3 - 5.8	4.9 - 5.3	$483	$94	$203	$244
350	308	6.1 -6.7	5.6 - 6.1	$414	$81	$188	$227
400	352	6.9 - 7.5	6.4 - 6.9	$363	$71	$176	$217

Table 5c. Estimated Milking Shifts and Costs For a Double-8 Herringbone Parlor

Assumptions:

Milking Center Cost = $200,000

Steady-State Throughput = 65 to 72 cows per hour

Milking Time Throughput = 59 to 65 cows per hour

Chore Time for Set-Up and Clean-Up = 0.5 hour

Labor Costs Based on $8 per Hour.

TOTAL HERD SIZE	COWS MILKED PER DAY (88% in milk)	ESTIMATED MILKING SHIFT (hours)		INVESTMENT PER COW	ANNUAL FIXED COST PER COW	TOTAL ANNUAL COSTS PER COW	
		2X	3X			2X	3X
150	132	2.7 - 2.5	2.3 - 2.5	$1,333	$238	$339	$378
200	176	3.2 - 3.5	2.9 - 3.2	$1,000	$178	$276	$312
250	220	3.9 - 4.2	3.6 - 3.9	$800	$143	$238	$274
300	264	4.6 - 5.0	4.2 - 4.6	$667	$129	$222	$257
350	308	5.2 - 5.7	4.8 - 5.2	$571	$111	$202	$236
400	352	5.9 - 6.5	5.4 - 5.9	$500	$97	$188	$221
450	396	6.6 - 7.2	6.0 - 6.6	$444	$86	$176	$209
500	440	7.3 - 8.0	6.5 - 7.3	$400	$78	$167	$199

Table 5d. Estimated Milking Shifts and Costs For a Double-10 Herringbone Parlor With Rapid Exit

Assumptions:
Milking Center Cost = $265,000
Steady-State Throughput = 75 to 80 cows per hour
Milking Time Throughput = 68 to 72 cows per hour
Chore Time for Set-Up and Clean-Up = 0.5 hour
Labor Costs Based on $8 per Hour.

TOTAL HERD SIZE	COWS MILKED PER DAY (88% in milk)	ESTIMATED MILKING SHIFT (hours)		INVESTMENT PER COW	ANNUAL FIXED COST PER COW	TOTAL ANNUAL COSTS PER COW	
		2X	3X			2X	3X
150	132	2.3 - 2.4	2.2 - 2.3	$1,767	$315	$406	$446
200	176	2.9 - 3.1	2.7 - 2.8	$1,325	$236	$324	$356
250	220	3.6 - 3.7	3.3 - 3.4	$1,060	$189	$274	$306
300	264	4.2 - 4.4	3.8 - 4.0	$883	$172	$256	$286
350	308	4.8 - 5.0	4.4 - 4.6	$757	$147	$229	$260
400	352	5.4 - 5.7	4.9 - 5.2	$663	$129	$210	$240
500	440	6.6 - 7.0	6.0 - 6.4	$530	$103	$182	$212
600	528	7.8 - 8.3	7.1 - 7.5	$442	$86	$164	$193

Practical Implications For Herringbone Parlors

The values in Tables 5a through 5d point out the strong economies of scale that exist for pitted parlors. The majority of the economies of scale are obtained once the investment per cow is below $600. Comparison of the total annual costs (fixed + labor) for double-4 and double 6 herringbone parlors indicates that labor costs also must be considered. For herd sizes from 150 to 250 cows the double-4 provides the lowest fixed cost per cow, but the total annual costs are lower for the double-6 because the throughput is significantly higher resulting in lower labor costs. The negative impact of the higher labor costs for double-4 parlors is amplified if the producer plans to milk cows 3X. In fact, a double-6 herringbone is the least cost parlor, included in the analysis, for herd sizes from 150 to 400 cows. The majority of the economies of scale can be obtained using a double-6 herringbone for herd sizes of 250 to 300 cows as indicated by fixed costs of $113 per cow or less. Consequently, a double-6 is the recommended herringbone parlor for dairies with ultimate herd sizes of 200 to 350 cows. If the ultimate herd size will be between 350 and 500 cows then a double-8 is recommended. Double-10 parlors are best utilized for herds ranging in size from 450 to 600 cows.

Table 6a. Estimated Milking Shifts and Costs For a Double-6 Flat Parlor
Assumptions:
Milking Center Cost Including Bulk Tank:
Flat Parlor in Renovated Stall Barn (REN) = $34,000
New Building and Flat Parlor= $60,000
Milking Time Throughput = 35 to 40 cows per hour
Chore Time for Set-Up and Clean-Up = 0.5 hour
Labor Costs Based on $8 per Hour.

TOTAL HERD SIZE	COWS MILKED PER DAY (88% in milk)	ESTIMATED MILKING SHIFT (hours)	INVESTMENT PER COW		ANNUAL FIXED COST PER COW		TOTAL ANNUAL COSTS PER COW	
		2X	REN	NEW	REN	NEW	REN	NEW
70	62	2.1 - 2.3	$486	$857	$101	$145	$285	$329
100	88	2.7 - 3.0	$340	$600	$70	$101	$236	$267
120	106	3.2 - 3.5	$283	$500	$59	$84	$222	$247

Table 6b. Estimated Milking Shifts and Costs For a Double-8 Flat Parlor
Assumptions:
Milking Center Cost Including Bulk Tank:
Flat Parlor in Renovated Stall Barn (REN) = $38,000
New Building = $65,000
Milking Time Throughput = 45 to 50 cows per hour
Chore Time for Set-Up and Clean-Up = 0.5 hour
Labor Costs Based on $8 per Hour.

TOTAL HERD SIZE	COWS MILKED PER DAY (88% in milk)	ESTIMATED MILKING SHIFT (hours)	INVESTMENT PER COW		ANNUAL FIXED COST PER COW		TOTAL ANNUAL COSTS PER COW	
		2X	REN	NEW	REN	NEW	REN	NEW
70	62	1.7 - 1.9	$543	$929	$112	$159	$262	$309
100	88	2.3 - 2.5	$380	$650	$79	$111	$220	$251
120	106	2.6 - 2.9	$317	$542	$66	$93	$200	$227
150	132	3.1 - 3.4	$253	$433	$52	$74	$179	$201

Practical Implications for Flat Parlors

The results for herringbone parlors indicated that in order for small dairies to be competitive the: (1) investment per cow in milking system should be less than $600 per cow; (2) annual fixed costs per cow should be less than $140 per cow; and (3) throughput rate should be at least 50 cows per person per

hour for herds greater than 120 cows. The calculations for flat parlors in Tables 6a and 6b indicate the following.

(1) A double-6 flat parlor built in a renovated stall barn for herd sizes of 70 to 120 cows has the same or lower annual costs as a double-6 herringbone for a 300 to 400 cow herd or a double-10 for a 500 cow herd.

(2) Double-8 flat parlors built in a renovated stall barn are the most cost effective for herd sizes of 100 to 150 cows.

(3) Double-6 or 8 flat parlors built in new buildings may be a good option for herd sizes of 100 to 150 cows.

(4) Using a renovated stall barn for a flat parlor to milk 100 to 150 cows instead of investing in a double-4 or 6 herringbone provides an annual fixed costs savings ranging from $11,000 to $18,150 per year.

(5) The milking shifts for double-6 and double-8 flat parlors are similar to those for a double-4 or double-6 herringbone parlors.

(6) Using a double-8 flat parlor in a new building for a herd size of 150 cows instead of a double-6 herringbone results in an annual fixed cost savings of $14,850 and a total annual cost savings of $16,650.

Summary

Flat parlors provide a powerful risk reduction strategy for dairy producers that are in transition from stall barns to free stall and parlor systems. It allows the producer to obtain the same annual costs as large dairies in the beginning of the transition. If herd sizes are limited to 120 cows or less the flat parlor may become the long-term option allowing the small dairy to be competitive with 500 cow dairies. Flat parlors address one of the most critical factors regarding the goal of increasing the number of cows that can be managed per worker by increasing the rate at which cows are milked by a factor of two.

PLANNING FREE STALL HOUSING BASED ON MANAGEMENT

In many situations the primary factors used to select the type and layout of the free stall building are: (1) cost, (2) what works for neighbors, and (3) cost. As a result, the factors that directly relate to the management of cows are not given adequate emphasis and the present and future nutritional, or herd health programs may be negatively influenced by the layout of the facilities. Instead, plan the management groups and then build the barn to fit.

Use Fence Line Feeding

In most cases the free stall facility should be built to allow fence line feeding with a TMR wagon or power cart. Cows not only consume more feed at a feeding fence (Albright, 1993), but fence line feeding with a cart or wagon greatly reduces the amount of time required to feed cows. The result is that the number of cows that can be managed per worker is increased. (See Figure 8 for major dimensions.)

Planning Based on Management Groups

Even at the beginning of a step-wise transition from a 40 cow stall barn to a 250 cow free stall and parlor system the types of management groups in the transition step and the ultimate step should be considered. In fact, the best approach would be to: (1) make preliminary decisions on how cows should be grouped for the ultimate herd size, (2) plan the facilities for those groups, and (3) then select the

part of the free stall unit that will be built first as part of the transition step. One of the advantages of free stall buildings is that they can be built in a a large variety of configurations based on the management style of the producer or management consultant. A set of multipliers were developed to assist in the planning process and are given in Table 7. Use the values in the table as a starting point and then fine tune based on the needs of a particular herd. Cow groups that are suggested are based on nutrition and reproduction. More groups can be used than shown - especially on larger herds. Table 8a and 8b are provided to assist in planning pen sizes. Recommendation for numbers of water tanks, and walk throughs are indicated with the tables.

Table 7. Estimation of Management Groups for Planning Free Stall Housing Systems (Linn and Reneau, 1994).

Assumptions: (1) 13 month calving interval, (2) 88% of the herd lactating, (3) cull rate is 33%.

LINE NO.	ANIMAL CATEGORY						CALCULATION SPACE	FORMULA
L1	TOTAL HERD	70	100	150	300	500		
L2	LACTATING COWS	62	88	132	264	440		(L1 X 0.88)
L3	TOTAL DRY COWS	8	12	18	36	60		(L1 - L2)
L4	CLOSE-UP DRY COWS	3	5	7	14	24		(L3 X 0.4)
L5	FAR-OFF DRY COWS	5	7	11	25	36		(L3 - L4)
L6	FRESH COWS	3	5	7	14	24		= L4
L7	COWS BEING DRIED OFF	2	3	4	7	12		(L6 / 2)
L8	TOTAL NUMBER OF HEIFERS	23	33	50	100	167		(L1 / 3)
L9	HEIFERS FOR HIGH GROUP	17	24	37	73	122		(L8 X 0.73)
L10	HEIFERS FOR LOW GROUP	6	9	13	27	45		(L8 - L9)
L11	TOTAL NUMBER OF OLDER COWS FOR GROUPING	34	47	71	143	237		(L2 - L6 - L7 - L8)
L12	HIGH GROUP COWS	20	28	43	86	142		(L11 X 0.6)
L13	LOW GROUP COWS	14	19	28	57	95		(L11 - L12)

Table 8a. Number of Free Stalls Provided For Common Pen or Building Lengths if Dividers are Hung 44 to 45 inches On-Center [a] .

BUILDING OR PEN LENGTH. ft	TWO ROWS TAIL-TO-TAIL	TWO ROWS HEAD-TO-HEAD	THREE ROWS
72	32 (33)	26 (28)	45 (47)
84	38 (39)	32 (34)	54 (56)
96	45 (46)	38 (40)	64
108	51	44	73
120	58	52	84
132	64	58	93
144	71	64	[99]
156	77	70	[108]
168	84	78	{117}
180	90	84	{124}
192	[95]	[86]	{134}
204	[101]	[92]	{143}
216	[108]	[100]	{154}

[a] Numbers without brackets denote the use of 12 ft walk throughs on both ends of the building and at least one water tank for every 40 to 50 cows.

( ) Denotes use of a 12 ft and 8 ft wide walk throughs on the ends of the building.

[ ] Denotes the need for a center walk through that is as wide as two stalls.

{} Denotes the need for a 12 ft wide center walk through and a third water tank.

Table 8b. Number of Free Stalls Provided For Common Pen or Building Lengths if Dividers are Hung 48 inches On-Center [a] .

BUILDING OR PEN LENGTH. ft	TWO ROWS TAIL-TO-TAIL	TWO ROWS HEAD-TO-HEAD	THREE ROWS
72	30 (31)	24 (26)	42 (44)
84	36 (37)	30 (32)	51 (53)
96	42 (43)	36 (48)	60
108	48 (49)	42 (44)	69
120	54	48	78
132	60	54	87
144	66	60	96
156	72	66	[101]
168	78	72	[110]
180	84	78	{117}
192	90	84	{126}
204	[94]	[86]	{135}
216	[100]	[92]	{144}

[a] Numbers without brackets denote the use of 12 ft walk throughs on both ends of the building and at least one water tank for every 40 to 50 cows.

( ) Denotes use of a 12 ft and 8 ft wide walk throughs on the ends of the building.

[ ] Denotes the need for a center walk through that is as wide as two stalls.

{} Denotes the need for a 12 ft wide center walk through and a third water tank.

The impact of planning the barn around the groups instead of planning the groups around the barn is that the type and layout of the building will, in many cases, be significantly different from the drive through barns with equal pen sizes that are commonly used. The impact of planning the groups before the barn is best shown by example. In Table 7 the various cow and heifer groups are calculated for total herd sizes of 70, 150, and 300 cows. Concept diagrams of how free stall facilities could be constructed for these three herds are provided in Figures 5 through 7. Stocking rates, feeding space per cow, and restraint facilities for daily treatment are also included in the concept diagrams.

Discussion of the 70 Cow Plan

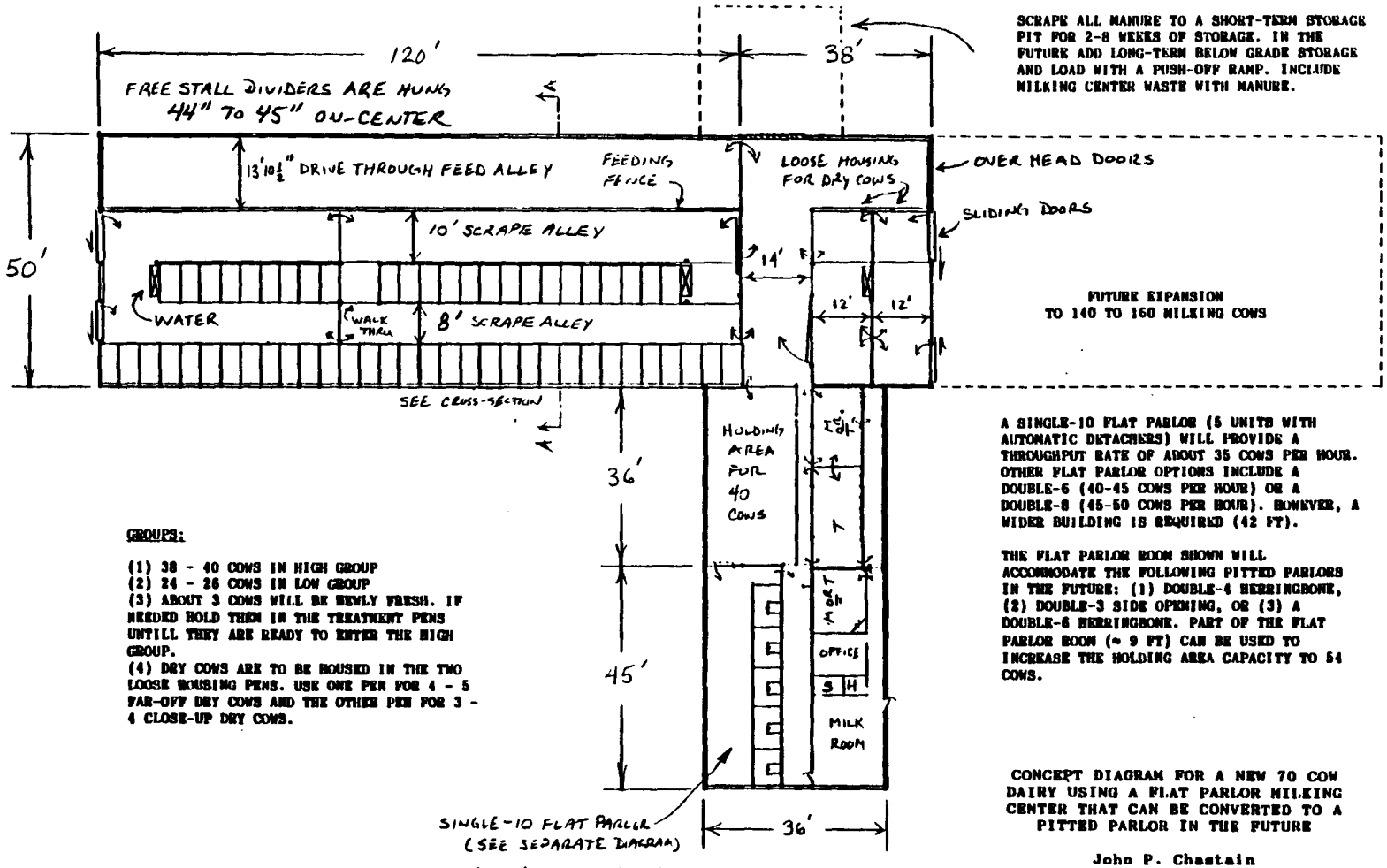
For small herds it is often impractical to provide more than to lactating groups and two dry groups in the housing area. Therefore, fresh cows will be held as long as required (about 2 weeks) in the treatment pens along the side of the holding area. In most cases a new flat parlor would not be used with the free stall barn. Instead, provide pens for fresh cows in the existing stall barn with the flat parlor if possible. On the average their will be 1 to 2 cows being dried off on a 70 cow dairy. Drying off cows would be milked once-a-day for a week and are fed a dry cow ration. In a small herd such as this, a simple way to manage drying off cows is to put them in the loose housing pen nearest the cross alley with a few dry cows. In the future, the building can be expanded to accommodate 100, 140 or possibly 160 lactating cows. The flat parlor milking center shown would be up graded to a double-4 or 6 herringbone at that time.

The stocking rates suggested range from 1.10 to 1.18 cows per stall. The length of the feeding fence for the high group is 75 ft. Therefore, the amount of feeding space provided is 22.5 to 23.7 inches per cow. The low group receives 20 to 22.5 inches per cow. A TMR is recommended. Lock-ups are not provided in the free stall barn. Instead they are provided in a treatment pen along the side of the holding area. A treatment pen with lock-ups can also be provides with a flat parlor in a stall barn if space permits.

Discussion of the 150 Cow Plan

When lactating groups are housed on each side of the cross alley it is often best to house dry cows in another facility. For the case show in Figure 6 it is assumed that the stall barn has been converted to a maternity and treatment facility. Existing heifer barns could be used for close-up and far-off dry cows and heifers above 2 months of age are contract raised. The stocking rates, and resultant feeding space, and group placement is indicated in the figure. The holding area is sized to allow the four groups in the free stall barn to be milked as two large groups. The groups in each wing of the free stall barn would be kept separate using the crowd gate. A few cows will spend 1.4 hours in the holding pen. However, the time required for feeding the high group rations and scraping manure will be significantly reduced. During periods of heat stress the heifer and high groups could be milked separately if desired. Grouping the cows into 4 management groups, but planning to allow them to be moved to the milking center as two groups will help to maximize the number of cows that can be managed per worker. Lock-ups are not needed in the free stall area since a pit operated sort gate is used to divert cows to a catch lane or the group treatment pen as they exit the parlor room. *If should be noted that the grouping strategy indicated in Figure 6 could not be obtained for 132 lactating cows in any center drive through barn.*

This barn could be expanded to hold 160 lactating cows by adding on to the east wing. Additional barns can be added in the future to expand the herd to 300 cows.



SCRAPE ALL MANURE TO A SHORT-TERM STORAGE PIT FOR 2-8 WEEKS OF STORAGE. IN THE FUTURE ADD LONG-TERM BELOW GRADE STORAGE AND LOAD WITH A PUSH-OFF RAMP. INCLUDE MILKING CENTER WASTE WITH MANURE.

A SINGLE-10 FLAT PARLOR (5 UNITS WITH AUTOMATIC DETACHERS) WILL PROVIDE A THROUGHPUT RATE OF ABOUT 35 COWS PER HOUR. OTHER FLAT PARLOR OPTIONS INCLUDE A DOUBLE-6 (40-45 COWS PER HOUR) OR A DOUBLE-8 (45-50 COWS PER HOUR). HOWEVER, A WIDER BUILDING IS REQUIRED (42 FT).

THE FLAT PARLOR ROOM SHOWN WILL ACCOMMODATE THE FOLLOWING PITTED PARLORS IN THE FUTURE: (1) DOUBLE-4 HERRINGBONE, (2) DOUBLE-3 SIDE OPENING, OR (3) A DOUBLE-6 HERRINGBONE. PART OF THE FLAT PARLOR ROOM (≈ 9 FT) CAN BE USED TO INCREASE THE HOLDING AREA CAPACITY TO 54 COWS.

N

GROUPS:

(1) 38 - 40 COWS IN HIGH GROUP
(2) 24 - 26 COWS IN LOW GROUP
(3) ABOUT 3 COWS WILL BE NEWLY FRESH. IF NEEDED HOLD THEM IN THE TREATMENT PENS UNTILL THEY ARE READY TO ENTER THE HIGH GROUP.
(4) DRY COWS ARE TO BE HOUSED IN THE TWO LOOSE HOUSING PENS. USE ONE PEN FOR 4 - 5 FAR-OFF DRY COWS AND THE OTHER PEN FOR 3 - 4 CLOSE-UP DRY COWS.

CONCEPT DIAGRAM FOR A NEW 70 COW DAIRY USING A FLAT PARLOR MILKING CENTER THAT CAN BE CONVERTED TO A PITTED PARLOR IN THE FUTURE

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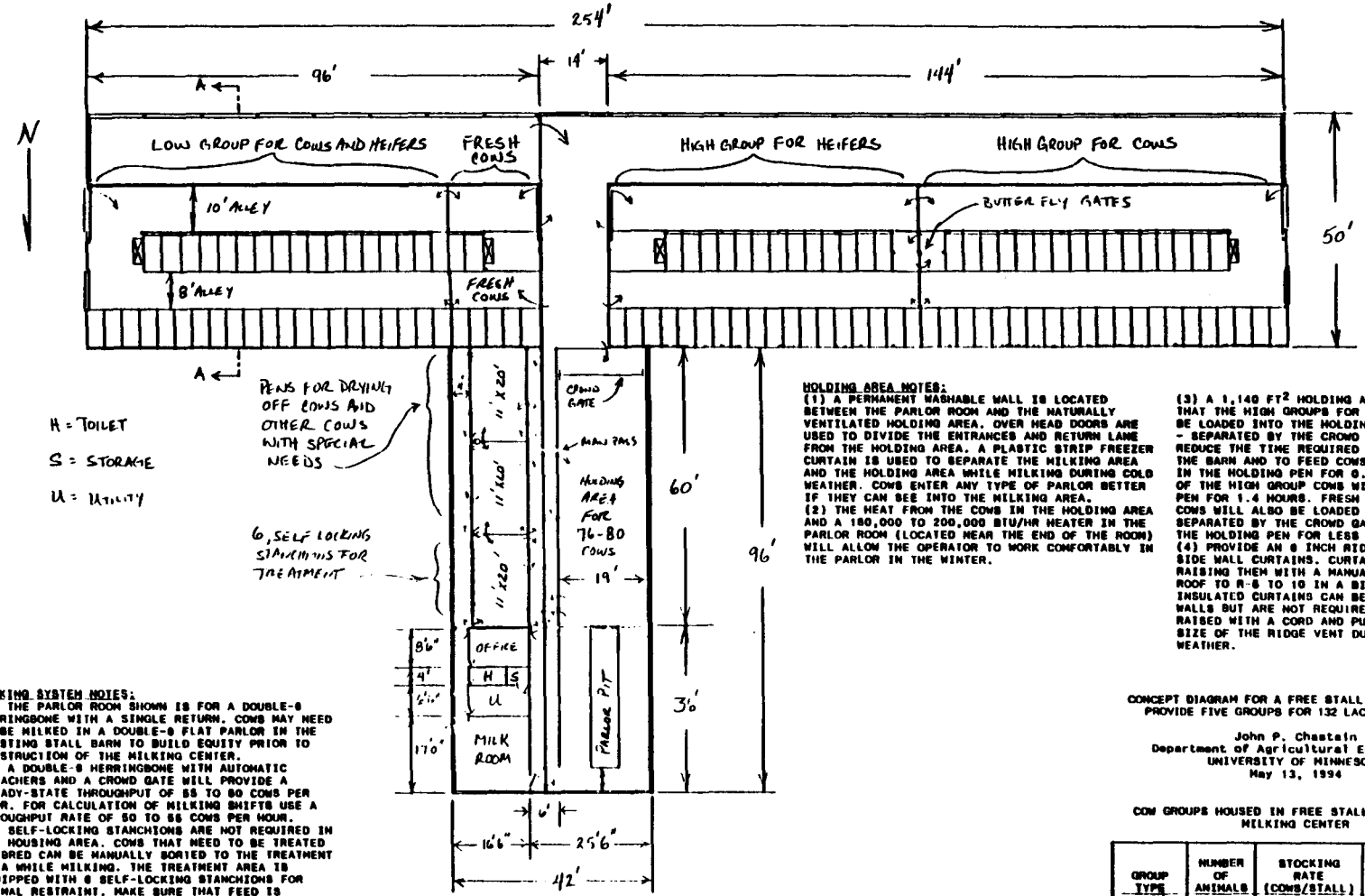
May 4, 1994

Figure 5



HOLDING AREA NOTES:
(1) A PERMANENT WASHABLE WALL IS LOCATED BETWEEN THE PARLOR ROOM AND THE NATURALLY VENTILATED HOLDING AREA. OVER HEAD DOORS ARE USED TO DIVIDE THE ENTRANCES AND RETURN LANE FROM THE HOLDING AREA. A PLASTIC STRIP FREEZER CURTAIN IS USED TO SEPARATE THE MILKING AREA AND THE HOLDING AREA WHILE MILKING DURING COLD WEATHER. COWS ENTER ANY TYPE OF PARLOR BETTER IF THEY CAN SEE INTO THE MILKING AREA.
(2) THE HEAT FROM THE COWS IN THE HOLDING AREA AND A 180,000 TO 200,000 BTU/HR HEATER IN THE PARLOR ROOM (LOCATED NEAR THE END OF THE ROOM) WILL ALLOW THE OPERATOR TO WORK COMFORTABLY IN THE PARLOR IN THE WINTER.
(3) A 1,140 FT^2 HOLDING AREA IS PROVIDED SO THAT THE HIGH GROUPS FOR COWS AND HEIFERS CAN BE LOADED INTO THE HOLDING PEN AT THE SAME TIME - SEPARATED BY THE CROWD GATE. THIS WAS DONE TO REDUCE THE TIME REQUIRED TO SCRAPE MANURE FROM THE BARN AND TO FEED COWS. THE HEIFERS WILL BE IN THE HOLDING PEN FOR 0.84 HOURS AND THE LAST OF THE HIGH GROUP COWS WILL BE IN THE HOLDING PEN FOR 1.4 HOURS. FRESH COWS AND LOW GROUP COWS WILL ALSO BE LOADED INTO THE HOLDING PEN SEPARATED BY THE CROWD GATE. THEY WILL BE IN THE HOLDING PEN FOR LESS THAN 0.5 HOURS.
(4) PROVIDE AN 8 INCH RIDGE VENT AND ADJUSTABLE SIDE WALL CURTAINS. CURTAINS ARE CLOSED BY RAISING THEM WITH A MANUAL WINCH. INSULATE THE ROOF TO R-8 TO 10 IN A BIRD-PROOF MANNER. INSULATED CURTAINS CAN BE USED ON THE SIDE WALLS BUT ARE NOT REQUIRED. A PVC PIPE CAN BE RAISED WITH A CORD AND PULLEYS TO REDUCE THE SIZE OF THE RIDGE VENT DURING EXTREMELY COLD WEATHER.

MILKING SYSTEM NOTES:
(1) THE PARLOR ROOM SHOWN IS FOR A DOUBLE-8 HERRINGBONE WITH A SINGLE RETURN. COWS MAY NEED TO BE MILKED IN A DOUBLE-8 FLAT PARLOR IN THE EXISTING STALL BARN TO BUILD EQUITY PRIOR TO CONSTRUCTION OF THE MILKING CENTER.
(2) A DOUBLE-8 HERRINGBONE WITH AUTOMATIC DETACHERS AND A CROWD GATE WILL PROVIDE A STEADY-STATE THROUGHPUT OF 65 TO 80 COWS PER HOUR. FOR CALCULATION OF MILKING SHIFTS USE A THROUGHPUT RATE OF 50 TO 55 COWS PER HOUR.
(3) SELF-LOCKING STANCHIONS ARE NOT REQUIRED IN THE HOUSING AREA. COWS THAT NEED TO BE TREATED OR BRED CAN BE MANUALLY SORTED TO THE TREATMENT AREA WHILE MILKING. THE TREATMENT AREA IS EQUIPPED WITH 6 SELF-LOCKING STANCHIONS FOR ANIMAL RESTRAINT. MAKE SURE THAT FEED IS AVAILABLE IF THE COWS WILL BE WAITING FOR THE VETERINARIAN.
(4)PROVIDE 1,200 CFM OF EXHAUST OR NEUTRAL PRESSURE VENTILATION IN THE WINTER. USE POSITIVE VENTILATION DURING SUMMER TO PROVIDE AT LEAST 6,000 CFM OF AIRFLOW.

FREE STALL NOTES:
(1) DIVIDERS ON THE OUTSIDE WALLS ARE HUNG 44.3 INCHES ON-CENTER.
(2) DIVIDERS ON THE INSIDE ROWS ARE HUNG 45 TO 45.5 INCHES ON-CENTER.
(3) STALL LENGTH IS 7 FT 10.5 INCHES.
(4) NECK RAILS AND BRISKET BOARDS ARE REQUIRED AND ARE POSITIONED 66 INCHES FROM THE REAR CURB.
(5) USE STRAIGHT OR WIDE SPAN LOOPS HUNG 42 TO 44 INCHES ABOVE THE STALL BASE.
(SEE CROSS-SECTION FOR ADDITIONAL DETAILS.)

CONCEPT DIAGRAM FOR A FREE STALL BARN BUILT TO PROVIDE FIVE GROUPS FOR 132 LACTATING COWS

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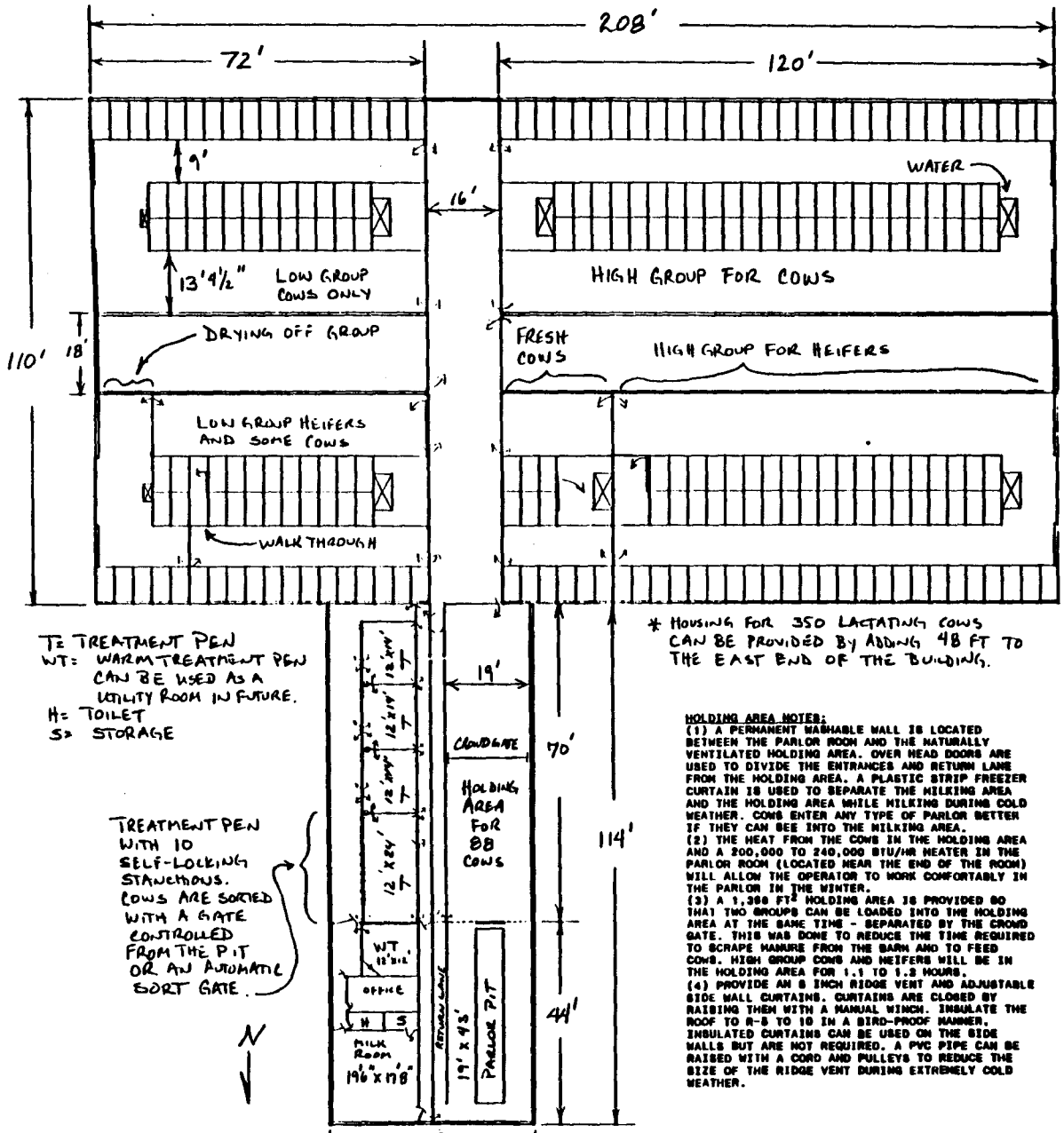
May 13, 1994

COW GROUPS HOUSED IN FREE STALLS OR PENS IN MILKING CENTER

GROUP TYPE	NUMBER OF ANIMALS	STOCKING RATE (COWS/STALL)	FEEDING SPACE (INCHES PER HEAD)
HIGH GROUP FOR COWS	42	1.14	22.2
HIGH GROUP FOR HEIFERS	36	1.13	22.6
LOW GROUP	44	1.19	21.1
FRESH COWS	7	1.0	31.9
DRYING OFF COWS	4	73 TO 110 FT^2 / COW	< 36

OTHER BUILDINGS ARE REQUIRED FOR:
(1) 11 TO 14 FAR-OFF DRY COWS,
(2) 7 TO 10 CLOSE-UP DRY COWS,
(3) MATERNITY PENS, AND
(4) TREATMENT PENS FOR COLD WEATHER SURGERY.

Figure 6



* HOUSING FOR 350 LACTATING COWS CAN BE PROVIDED BY ADDING 48 FT TO THE EAST END OF THE BUILDING.

HOLDING AREA NOTES:
(1) A PERMANENT WASHABLE WALL IS LOCATED BETWEEN THE PARLOR ROOM AND THE NATURALLY VENTILATED HOLDING AREA. OVER HEAD DOORS ARE USED TO DIVIDE THE ENTRANCES AND RETURN LANE FROM THE HOLDING AREA. A PLASTIC STRIP FREEZER CURTAIN IS USED TO SEPARATE THE MILKING AREA AND THE HOLDING AREA WHILE MILKING DURING COLD WEATHER. COWS ENTER ANY TYPE OF PARLOR BETTER IF THEY CAN SEE INTO THE MILKING AREA.
(2) THE HEAT FROM THE COWS IN THE HOLDING AREA AND A 200,000 TO 240,000 BTU/HR HEATER IN THE PARLOR ROOM (LOCATED NEAR THE END OF THE ROOM) WILL ALLOW THE OPERATOR TO WORK COMFORTABLY IN THE PARLOR IN THE WINTER.
(3) A 1,300 FT^2 HOLDING AREA IS PROVIDED SO THAT TWO GROUPS CAN BE LOADED INTO THE HOLDING AREA AT THE SAME TIME - SEPARATED BY THE CROWD GATE. THIS WAS DONE TO REDUCE THE TIME REQUIRED TO SCRAPE MANURE FROM THE BARN AND TO FEED COWS. HIGH GROUP COWS AND HEIFERS WILL BE IN THE HOLDING AREA FOR 1.1 TO 1.3 HOURS.
(4) PROVIDE AN 8 INCH RIDGE VENT AND ADJUSTABLE SIDE WALL CURTAINS. CURTAINS ARE CLOSED BY RAISING THEM WITH A MANUAL WINCH. INSULATE THE ROOF TO R-5 TO 10 IN A BIRD-PROOF MANNER. INSULATED CURTAINS CAN BE USED ON THE SIDE WALLS BUT ARE NOT REQUIRED. A PVC PIPE CAN BE RAISED WITH A CORD AND PULLEYS TO REDUCE THE SIZE OF THE RIDGE VENT DURING EXTREMELY COLD WEATHER.

FREE STALL NOTES:
(1) BARN IS SHOWN WITH 234 FREE STALLS HUNG 48 INCHES ON-CENTER. IF THE STALL DIVIDERS ARE HUNG 44 TO 46 INCHES ON-CENTER THE TOTAL NUMBER OF STALLS WOULD BE 252.
(2) STALL LENGTH ALONG THE OUTSIDE WALLS IS 8 FT. HEAD-TO-HEAD STALLS ARE 7.8 FT LONG.
(3) NECK RAILS AND BRISKET BOARDS ARE REQUIRED AND ARE POSITIONED 68 INCHES FROM THE REAR CURB.
(4) USE STRAIGHT OR WIDE SPAN LOOPS HUNG 42 TO 44 INCHES ABOVE THE STALL BASE.
(5) REAR CURB IS 10 INCHES HIGH.

MILKING SYSTEM NOTES:
(1) THE PARLOR ROOM SHOWN IS FOR A DOUBLE-8 HERRINGBONE WITH A SINGLE RETURN.
(2) AN AUTOMATED DOUBLE-8 HERRINGBONE WILL PROVIDE A STEADY-STATE THROUGHPUT OF 67 TO 72 COWS PER HOUR. FOR CALCULATION OF MILKING SHIFTS USE A THROUGHPUT RATE OF 60 TO 66 COWS PER HOUR.
(3) SELF-LOCKING STANCHIONS ARE NOT REQUIRED IN THE HOUSING AREA. COWS THAT NEED TO BE TREATED OR BRED CAN BE SORTED TO THE TREATMENT AREA WHILE MILKING. THE TREATMENT AREA IS EQUIPPED WITH 10 SELF-LOCKING STANCHIONS FOR ANIMAL RESTRAINT. MAKE SURE THAT FEED IS AVAILABLE IF THE COWS WILL BE WAITING FOR THE VETERINARIAN.
(4)PROVIDE 1,600 CFM OF EXHAUST OR NEUTRAL PRESSURE VENTILATION IN THE WINTER. USE POSITIVE VENTILATION DURING SUMMER TO PROVIDE AT LEAST 8,000 CFM OF AIRFLOW.

CONCEPT DIAGRAM FOR A SIX ROW FREE STALL BARN BUILT TO PROVIDE SIX GROUPS FOR 264 LACTATING COWS
TOTAL HERD SIZE IS 300

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May 16, 1984

COW GROUPS HOUSED IN THE FREE STALL BARN

GROUP TYPE	NUMBER OF ANIMALS	STOCKING RATE (COWS/STALL)	FEEDING SPACE (INCHES PER HEAD)
HIGH GROUP FOR COWS	80 - 86	1.03 - 1.13	16.4 - 18.0
HIGH GROUP FOR HEIFERS	64 - 72	1.03 - 1.16	16.0 - 18.0
LOW GROUP COWS ONLY	46 - 57	1.14 - 1.36	15.2 - 18.0
LOW GROUP HEIFERS AND SOME COWS	36 - 42	1.13 - 1.35	14.8 - 17.6
FRESH COWS	14	1.170	20.8
DRYING OFF COWS	7	1.0	20.8

OTHER BUILDINGS ARE REQUIRED FOR:
(1) 25 TO 28 FAR-OFF DRY COWS,
(2) 14 TO 18 CLOSE-UP DRY COWS,
(3) MATERNITY PENS, AND
(4) TREATMENT PENS FOR COLD WEATHER NURSERY.

Figure 7

Discussion of the 300 Cow Plan

Six management groups are provided in a 6-row free stall barn for 264 lactating cows, Figure 7. An additional low group was added that will be composed of mostly heifers, and the drying off group was added to the free stall area. Pens along the side of the holding area are reserved for treated or other cows with special needs. The holding area was sized to allow all of the cows in a quadrant to be moved to the milking center at about the same time to facilitate scraping of manure and feeding. Maternity, treatment, and dry cow facilities are provided in other buildings. Depending on the stocking rate the feeding space provided for the high groups ranges from 16 to 18 inches. Feeding space for low group cows ranges from 15 to 18 inches per animal.

Research conducted by Menzi and Chase (1994) indicates that restricting feeding space to 14.6 to 16 inches per head for 88 and 90 cow groups with a mean production level of 88 to 90 lb/cow/day does not effect frequency of bunk usage. In fact, cows typically only use the available feeding space 30% to 36% of a 24 hour day regardless of the amount of feeding space provided (Albright et al., 1981, Albright, 1993). In cool climates such as Minnesota and Wisconsin 3 and 6 row barns can and are being effectively used with herds producing 23,000 to 25,000 lb/cow/year. However, added heat stress concerns dictate that 6 row barns should not be used in hot climates such as Georgia, Florida, and Arizona.

During the transition phase the dairy producer would need to construct the west wing of the 6-row barn first. Dry cows, close-up dry cows and springing heifers would probably be housed in separate pens at the beginning of the transition. Adding on to the eat wing of the barn would allow expansion to 350 lactating cows. Adding additional barns would allow expansion to a total herd size of 500 cows.

Manure Handling in Transition

Manure is removed from the free stall alleys and holding area by tractor scrape during most transitions and it is the recommended manure collection method on dairies up to 500 cows. Initially, plan on providing a small storage for 1 to 8 weeks of manure. Load the storage by tractor scrape and unload with a ramp and loader. If a small manure storage is not included then the producer will not be able to scrape the free stall alleys twice-a-day and cow cleanliness will suffer. Even a small storage helps a producer to use time more efficiently since manure will not be need to be hauled every day. In the future, add 12 months of below grade storage for manure and milking center wastewater. The manure can be loaded o storage using a well designed push-off ramp, gravity flow pipe, or a pump. The reception pit required to transfer manure to storage by gravity or pumping can be added to the cross alley in the barn in the future. Wasting a small amount of concrete in the future is cheaper than installing a reception pit now in many cases. Design information for manure collection, transfer and storage is provided in the *Livestock Waste Facilities Handbook* (MWPS-18).

Natural Ventilation Guidelines for Cold Free Stall Barns

Natural ventilation is the most functional type of ventilation system for cold free stall barns. It allows the dairy producer to easily control moisture in winter, and reduce the effects of heat stress in summer.

Roof Slope and Sidewall Height

Provide a 4/12 slope for gable or peak roofs. A 3/12 slope will work for existing buildings that are to be remodeled for cold dairy housing and can be used for monoslope buildings. All naturally ventilated dairy buildings need a sidewall height of 10 ft or more. A 12 ft sidewall height is recommended in most cased for free stall barns wider than 48 to 50 ft.. A 14 ft sidewall is recommended 6 row barns.

Provide a 3 ft overhang along side walls adjacent to free stall pens. A 1 ft overhang is used on the sidewall that is adjacent to a drive through feed alley.

Ridge Vents

Size the ridge vent according to building width. Provide 2 inches of continuous ridge (or peak) opening for every 10 ft of building width. For example, a 40 ft wide building would require an 8 inch wide ridge vent. The minimum ridge vent size is 6 inches. Do not use a ridge cap because it will obstruct airflow. Protect the top of the trusses with metal flashing or a short piece of a metal ridge cap. Free stalls with center drive-through feed alleys do not require any structure to reduce the amount of precipitation that enters through the open ridge since it falls on the drive through alley. A large gutter can be built into the trusses 2 ft beneath the ridge vent on two or three row barns to reduce the amount of rain or snow that falls on stall surfaces. Monoslope two row barns can be used to eliminate this problem and are common in Pennsylvania. A concept diagram for a monoslope two row free stall barn with enclosed feeding is provided in Figure 8 and is the cross section of the buildings shown in Figures 5 and 6. Such a design has the following advantages: (1) the ridge vent is not over stalls or feed, (2) winter sun can penetrate into the resting area, and (3) a larger sidewall height can be provided on the south side to improve summer ventilation.

Eave Vents

Eave vents are used for winter ventilation along with the ridge vent (Figure 8 and 9). Size eave vents in a similar manner as ridge vents. Provide 1 inch of continuous eave opening per 10 ft of building width on each side of the building. If the eave is adjustable then it can be reduced to 1/2 inch per 10 ft of building weather when the highs are in the teens and the lows are below zero. During extremely cold weather (daily highs below zero) the eave vent can be temporarily reduced further - to perhaps 1 to 2 inches. However, moisture will probably condense on the under side of the roof. The eave vents must be opened again once the weather begins to warm. The only reason a producer would do this is to allow frozen manure to be scraped from the barn. In general, it is best to not adjust the eave vents except during extreme conditions. In general, neither the cows nor the building will be harmed by a few days of higher moisture. If ventilation is constricted for a large portion of the winter then the building will deteriorate faster and cows may suffer from respiratory disease.

Use Full Wall Ventilation in Summer

Provide full-wall ventilation in the summer. Curtains provide the easiest and least expensive method to provide open sidewalls during summer. Curtains can be rolled up in the summer manually or a hand operated winch can be used. Curtains controlled with thermostats do not work for cold free stall barns since moisture is the controlling factor not temperature. Double curtain sidewalls provide a convenient method to provide good wall ventilation and an adjustable eave vent in winter. A concept diagram for a double curtain wall is provided in Figure 9.

Insulation

In cold free stall barns insulation is not required in the southern half of Minnesota if properly sized ridge and eave vents are installed. In northern Minnesota, installing a small amount of insulation (up to R-5) beneath the metal roof will allow the eave vents to be closed to the smallest setting during extremely cold weather with fewer moisture problems. Insulation must be installed in a bird-proof, and cow-proof manner.

CONCEPT DIAGRAM FOR A MONOSLOPE
FREE STALL BARN WITH ENCLOSED FEEDING

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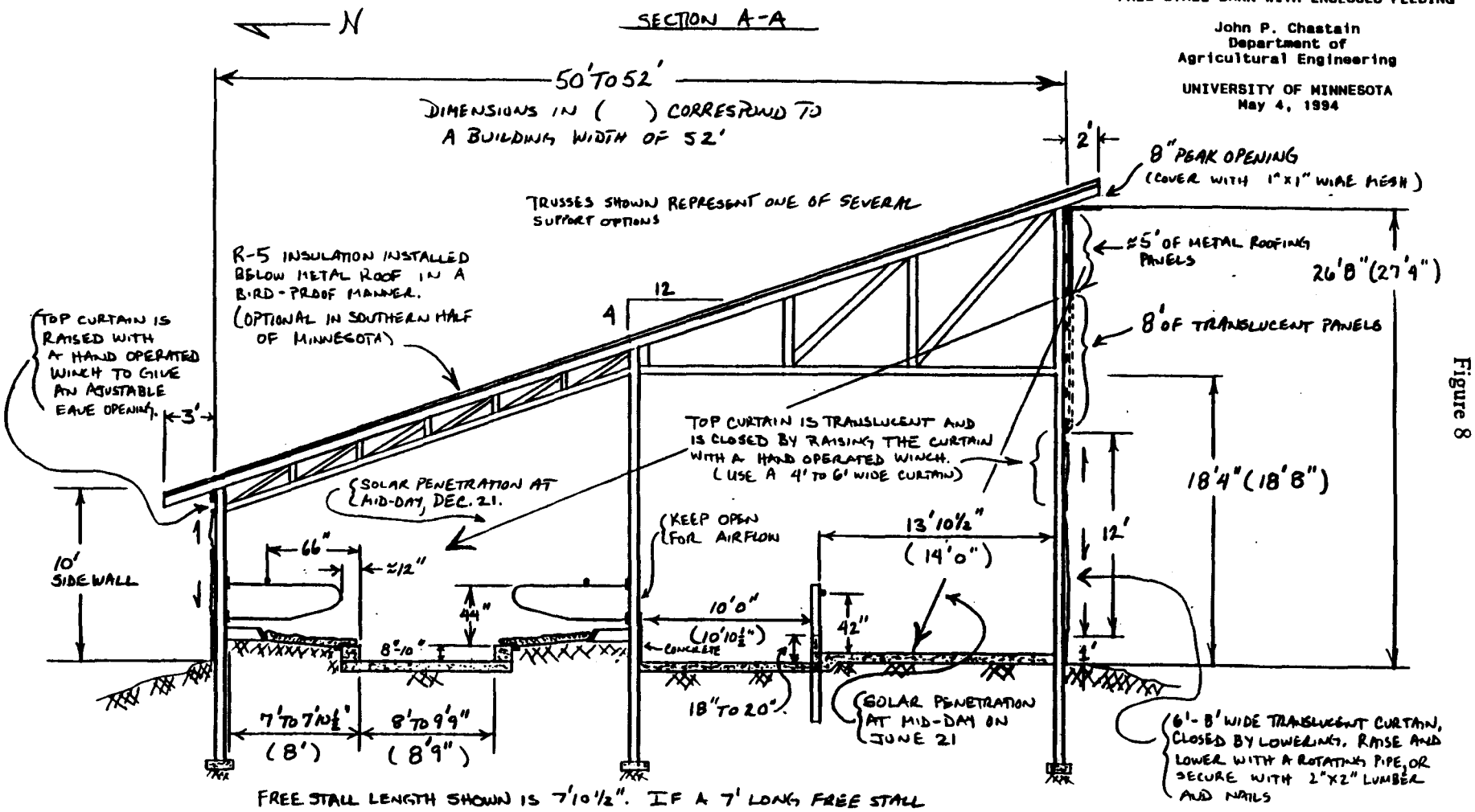
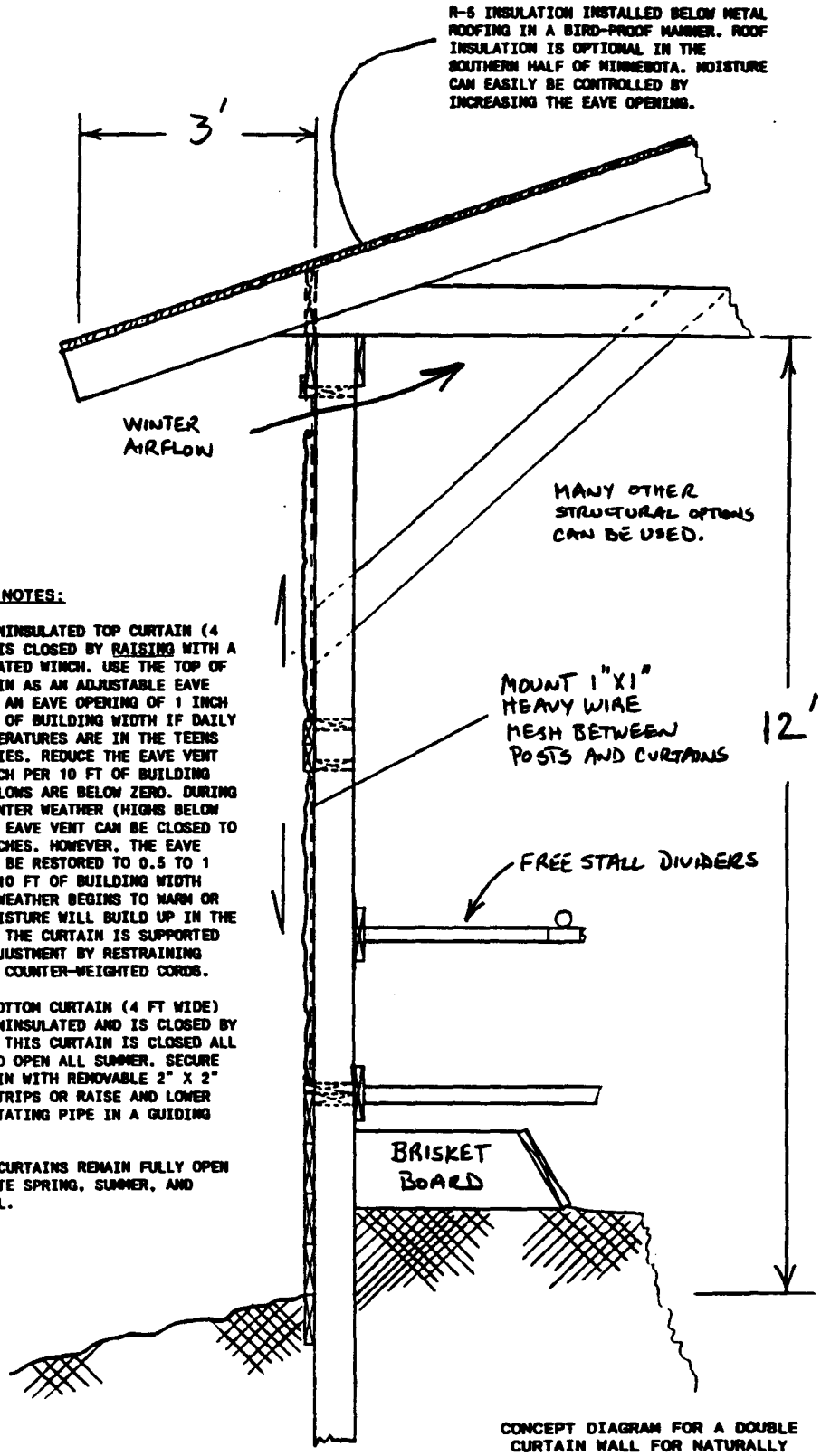
May 4, 1994



FREE STALL LENGTH SHOWN IS 7'10½". IF A 7' LONG FREE STALL IS USED THEN USE THE MICHIGAN OR DUTCH-STYLE FREE STALL PARTITION.

Figure 8

Figure 9



CURTAIN NOTES:

(1) THE UNINSULATED TOP CURTAIN (4 FT WIDE) IS CLOSED BY RAISING WITH A HAND OPERATED WINCH. USE THE TOP OF THE CURTAIN AS AN ADJUSTABLE EAVE VENT. USE AN EAVE OPENING OF 1 INCH PER 10 FT OF BUILDING WIDTH IF DAILY HIGH TEMPERATURES ARE IN THE TEENS AND TWENTIES. REDUCE THE EAVE VENT TO 0.5 INCH PER 10 FT OF BUILDING WIDTH IF LOWS ARE BELOW ZERO. DURING SEVERE WINTER WEATHER (HIGHS BELOW ZERO) THE EAVE VENT CAN BE CLOSED TO 1 TO 2 INCHES. HOWEVER, THE EAVE VENT MUST BE RESTORED TO 0.5 TO 1 INCH PER 10 FT OF BUILDING WIDTH WHEN THE WEATHER BEGINS TO WARM OR EXCESS MOISTURE WILL BUILD UP IN THE BUILDING. THE CURTAIN IS SUPPORTED DURING ADJUSTMENT BY RESTRAINING STRAPS OR COUNTER-WEIGHTED CORDS.

(2) THE BOTTOM CURTAIN (4 FT WIDE) IS ALSO UNINSULATED AND IS CLOSED BY LOWERING. THIS CURTAIN IS CLOSED ALL WINTER AND OPEN ALL SUMMER. SECURE THE CURTAIN WITH REMOVABLE 2" X 2" NAILING STRIPS OR RAISE AND LOWER WITH A ROTATING PIPE IN A GUIDING TRACK.

(3) BOTH CURTAINS REMAIN FULLY OPEN DURING LATE SPRING, SUMMER, AND EARLY FALL.

CONCEPT DIAGRAM FOR A DOUBLE CURTAIN WALL FOR NATURALLY VENTILATED DAIRY BUILDINGS

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SUMMARY

Making the transition from a stall barn to free stall housing system takes a great deal of careful planning. Flat parlors can provide an economically viable transition strategy for dairy producers that are planning to expand their herds to 250 cows or more. However, flat parlors can also be used to provide 70 to 150 cow dairies the same annual milking costs as 300 to 500 cow dairies. With careful planning the final result can be a facility that promotes good management of cows and incorporates proper waste handling structures. Consider all of the ventilation and waste management factors during the initial planning process and develop the manure application plan in the early stages. Realistically evaluate any labor or waste management constraints that may limit the size of the dairy and adjust the plan to maximize profitability.

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