Planning Freestall Facilities for the Expanding Dairy

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Across the United States and in many other parts of the world the trend to fewer but larger dairy farms is continuing. The definition of a "large dairy" differs by region. In parts of the Southeastern US a 2,000-cow dairy is considered to be large. In other regions, a dairy farm of about 500 cows is designated as large. However, even the most profitable dairy producers (greater than 20,000 lb/cow/year, 80 to 90% equity) find it difficult to expand the herd, build a new freestall barn, a new milking center, and add a modern waste handling system all at once. Expanding the dairy in steps is often the most feasible and profitable plan to follow. These various steps or phases in the expansion are sometimes referred to as the transition period. Planning the expansion and development of management and investment strategies to provide the most profitable transition period is often more difficult than simply building a new dairy all at once. Key elements that must be considered are definition of a realistic ultimate dairy size, and planning freestall housing facilities based on the desired cow management plan.

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 an expansion. Many times a producer, or even the veterinarian, will make a statement like "we plan to expand to 100 cows now but may decide 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 expansion. 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. The goal is to have the final dairy complex appear as if it was planned and built all at once.

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 regions manure will be applied on the dairy producer's farm as well as on cropland of neighbors, and as a result land base will not be the limiting factor. In areas where a strong tradition of crop production does not exist and the rural population is low utilization of manure nutrients and availability of labor 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 500 to 1000-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 encouraged 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 expansion. 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 new dairy production facility, and is directly linked to profitability. Most stall barn herds in the Midwest require 30 to 40 cows per worker. In freestall and parlor systems the number of cows per FTE can range from 30 to 80 cows per worker depending on facility design and management. Sixty to seventy cows per worker is a readily attainable goal for most well designed freestall and parlor systems. In order to develop a dairy housing system that will achieve 60-70 cows per worker, or more, labor must be used efficiently in the following areas: (1) milking cows, (2) feeding cows, (3) treatment and handling of cows, (4) 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 step-wise expansion. However, include in the plan locations for maternity areas (during pleasant and inclement weather), treatment facilities, heated areas for surgery in cold climates, and housing for heifers (or have them contract raised).

The basic questions that a dairy producer must consider at the beginning of the planning process are: (1) how many cows can be realistically managed per FTE for the proposed facility, (2) how many FTE's can family labor provide, and (3) how many people am I willing to learn how to manage? For example, if a producer is only willing to manage 2 FTE's of labor per day and can only contribute 1 FTE from the family then the maximum realistic herd size is in the range of 180 to 240 cows (60 to 80 cows/FTE).

A dairy producer must also weigh the required increase in fixed cost against a realistic estimate of the gain in overall efficiency. Examples of technologies that need to be evaluated are: manure flushing versus tractor scrape, or a double-8 herringbone parlor versus a double-10 parallel. The greatest pitfall is to overvalue the gain in efficiency and to undervalue the increase in risk related to the extra investment.

Estimates of Land Base Requirements

As stated previously, manure management is one of the factors that can limit the ultimate dairy size for a given site**.** In most states and provinces in North America regulatory agencies will require a detailed waste management plan that will provide an accounting of how the plant nutrients in dairy manure are utilized. Since forage production is still a significant enterprise on most dairy farms land application of manure is still a major consideration. If land and appropriate crops are limited then the dairy size will be limited. Traditionally manure has been viewed exclusively as a source of nitrogen. However, in some parts of the United States and some provinces in Canada, phosphorous is the limiting nutrient for land application.

The amount of nitrogen that must be managed per animal unit (1 animal unit, AU, = 1,000 lb live weight) depends on the ration fed, the methods use to handle and store manure, the amount of biological, physical, or chemical treatment provided by the manure management system, and the methods used to spread the manure on cropland. For example, liquid solid separation and lagoon treatment can reduce the amount of N that must be utilized in a land application system (e.g. Chastain et al., 1999; Chastain and Linvill, 1999; MWPS-18, 1993). The climate can also greatly effect how fast organic-N is mineralized in the soil and becomes available to the plant. A more detailed discussion of the availability of N can be found in several references (e.g. MWPS-18, 1993; Hilborn et al., 1998; Mikkelsen, et al., 1995). On the average, the amount of plant available nitrogen (PAN) that needs to be managed on a dairy farm ranges from 73 to 110 lb PAN/AU-year. The amount of P, expressed as P_2O_5, produced per AU varies greatly with the P content of the ration fed and can vary from 84 to 135 lb P_2O_5/AU-year.

The amount of land needed for application will vary with the types of crops grown and the historical yields on the farm (nutrient requirement increases as yield increases). Specific fertilizer recommendations are readily available from the Cooperative Extension Service, or published tables (e.g. MWPS-18, 1993). Corn silage typically requires 130 to 180 lb N/ac and 45 to 70 lb P_2O_5/ac (MWPS-18, 1993). However, the N requirement for small grains ranges from 70 to 125 lb N/ac and the P requirement ranges from 35 to 50 lb P_2O_5/ac. A conservative estimate of the amount of land needed based on N is 0.6 to 0.9 ac/AU (assuming 120 lb N/ac). If land application is limited based on P then the 1.7 to 2.7 ac/AU will be needed (assuming 50 lb P_2O_5/ac). The land requirements for a 500 cow dairy (Holsteins at 1,350 lb/cow) is about 506 acres based on N and 1,485 acres based on P.

PLANNING FREESTALL HOUSING BASED ON MANAGEMENT

In many situations the primary factors used to select the type and layout of the freestall building are: (1) cost and (2) what appears to "work" for neighbors. 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.

Even at the beginning of a step-wise expansion the types of management groups for the transition steps and the ultimate dairy size should be defined as accurately as possible. In fact, the best approach would be to: (1) make preliminary decisions on how cows should be grouped for the ultimate herd size, and (2) plan the facilities for those groups, and (3) then select the part of the freestall unit that will be built as the first, second, or third step. One of the advantages of freestall 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 was developed to assist in the planning process and are given in Table 1. Use the values in the table as a starting point and fine tune based on the needs of a particular herd. Cow groups suggested are based on stage of lactation, nutrition and reproduction. Provision of housing areas for cows with special needs (i.e. fresh cows, close-up dry cows, etc.) is an important but often overlooked factor in the development of a floor plan for new facilities. Grouping cows based on the energy content of the ration is becoming less important as herd averages climb to 24,000 to 30,000 lb/cow since maintenance of body condition takes priority. Instead, grouping to provide optimum management of 1st lactation heifers, and cows that are being bred is becoming more important.

The other issues that should be considered when selecting group sizes are the number of stalls per side in the parlor, and parlor throughput rate (cows/hr). In general, groups sizes should be an even multiple of the number of stalls on one side of the parlor for optimum efficiency. For example, if a double-10, rapid-exit herringbone parlor is being used then most of the groups should be a multiple of 10 (e.g. 80 cows). Plan to milk the odd sized group last to optimize parlor efficiency. It is also undesirable to require cows to spend more than 1.25 hours in the holding pen. Therefore, the group sizes should not exceed 1 to 1.25 times the throughput rate of the parlor. The amount of "parlor down-time" associated with group changes must be minimized to obtain optimum parlor efficiency. The number of groups should be kept to a minimum and the cow traffic lanes and holding pen should be designed so as to a group of cows to be loaded into the holding pen while 10 to 20% of the cows in the previous group are still being milked.

Table 1. Estimation of management groups for planning freestall housing. 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	100	300	500		
L2	Lactating cows	88	264	440		(L1 x 0.88)
L3	Total dry cows	12	36	60		(L1 - L2)
L4	Close-up dry cows	5	14	24		(L3 x 0.4)
L5	Far-off dry cows	7	25	36		(L3 - L4)
L6	Fresh cows	5	14	24		= L4
L7	Cows being dried off	3	7	12		(L6 / 2)
L8	Total 1st lactation heifers	33	100	167		(L1 / 3)
L9	Heifers for high group	24	73	122		(L8 x 0.73)
L10	Heifers for low group	9	27	45		(L8 - L9)
L11	Total older cows	47	143	237		(L2 - L6 - L7 - L8)
L12	High group cows	28	86	142		(L11 x 0.6)
L13	Low group cows	19	57	95		(L11 - L12)

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 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. A possible grouping plan for a 300 and 500 cow dairy is shown in Table 2. It was assumed that 4-row, drive-through freestall buildings will be used. Each quadrant of a building contains 1 or 2 groups. If 2 groups are specified the groups are divided by movable gates. If is also assumed that the stocking rate ranges from 1.12 to 1.2 cows per stall except for the fresh cow group. Use a stocking rate of 1.0 to 1.1 for fresh cows.

Table 2. Examples of possible grouping plans for a 300 and 500 cow dairy. Dry cows and close-up dry cows are housed in a separate facility.

300 Cow Dairy, Double-8 Herringbone Parlor, 1 Freestall Barn		No. of Cows	500 Cow Dairy, Double-10 Parallel Parlor, 2 Freestall Barns		No. of Cows
Quadrant 1	High-group cows	72	**Barn A**: Quadrant 1	High-group cows	80
Quadrant 2	High-group heifers	72	**Barn A**: Quadrant 2	Fresh cows	24
Quadrant 3	Low-group 1	64		High-group cows	56
Quadrant 4	Low-group 2, includes dry-off group, ID and milk 1X	42	**Barn A**: Quadrant 3	Heifer group 1	80
			Barn A: Quadrant 4	Heifer group 2	80
	Fresh cows – make small group with movable gates	14	**Barn B**: Section 1	Low-group 1	60
			Barn B: Section 2	Low-group 2	48
				Dry-off group	12

Discussion of the Example Grouping Plan for the 300 Cow Dairy

Five management groups are provided for 264 lactating cows. Three of the 5 groups are an even multiple of 8 to match the parlor size. The throughput rate for a well-automated double-8 herringbone is in the range of 60 to 65 cows/hr. Therefore, cows will be in the holding pen for 1.2 hours or less. Quadrant 3 and 4 are slightly smaller than quadrants 1 and 2 to facilitate the implementation of a fresh cow group and a second low group that contains the cows that are being dried off. On the average, 7 cows are being dried off for a 300-cow herd (Table 1) and it is difficult to justify a separate group. Proper identification of the cows being dried off will allow the milking center operator to avoid milking these cows in the evening as they come through the parlor. As herd size increases a separate dry cow group may be justified. Quadrants 1 and 2 would be constructed first in a step-wise expansion. Also addition of another freestall barn with 2 groups of 72 cows and well designed traffic lanes to and from the parlor will allow an expansion to 408 lactating cows and a total herd size of 464 cows without expanding the parlor.

Discussion of the Example Grouping Plan for the 500 Cow Dairy

In this case it was assumed that the dairy was located in a warm climate and that it was critical that the cows spend as little time in the milking center as was deemed economical. The throughput rate for a well-automated double-10 parallel parlor is in the range of 70 to 75 cows/hr. Therefore, the maximum time in the holding pen will be in the range of 1.07 to 1.14 hours. This constraint on maximum group size requires that two barns be used. In this case, a fresh cow group and a dry-off group are specified. However, the cows being dried off could be included in the second low-group if desired. In a step-wise expansion, barn A and the milking center would be built first followed by barn B. The maximum herd size for a double-10 assuming 3X milking is about 600 high-producing cows. If cows are milked 2X then the maximum herd size is about 800 cows.

OTHER ISSUES

Determination of a realistic dairy size based on site or management constraints, and planning the freestall facilities based on the desired management plan are critically important and are often not given adequate attention during the planning phase of an expansion. However, many other details such as freestall design, ventilation, comparison of freestall barn floor plans, provision of adequate watering space, provision of proper lighting for safety and photoperiod control, manure handling systems, floor surfacing, and others are also important. These important topics are given treatment by several publications including: MWPS-7 (1995), Smith et al. (1997), Chastain and Hiatt (1998), Chastain et al. (1997), Chastain et al. (1998), Chastain and Turner (1994), and Dahl et al., (1998).

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