DAIRY HERD HEALTH PROGRAMMING CONFERENCE

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The College of Veterinary Medicine
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BUILDING AND EQUIPMENT DESIGN TO PROMOTE ANIMAL HEALTH AND PRODUCTION

John F. Anderson, DVM, MS

Professor

Department of Large Animal Clinical Sciences

University of Minnesota

Livestock producers possess a wide variety of attitudes and managerial abilities. In addition, they are a very conservative segment of society. There are three close interrelationships which cause this attitude to prevail. They are first and foremost individualists. A family unit, in the past, survived as a result of being industrious in their labors and making wise decisions. If not, they were doomed to failure. Secondly, woven into this family fabric is the basic premise that "older and more experienced" family members make the major economic decisions. The third contributing factor which is pointed out repeatedly by producers is that they have often been sold poor quality merchandise or they have been given unsatisfactory advice. These unpleasant experiences then serve to reinforce "traditional conservatism." In short, these producers say, "So why should we believe the newcomer "consultant" who just happens to be a veterinarian?" As a profession, what we say "had better be the way it is" if we are to establish and maintain the highest credibility and professional respect.

A recent study published in *The Journal of the American Veterinary Medical Association* further reflects producer's attitudes. It stated that the livestock producer's perception of the local veterinarian's knowledge and cost-effectiveness, relative to alternative sources of information, are significant determinants of the choice for the first contact for assistance.[1] At least 7 out of 10 producers would contact a veterinarian first for diagnosis and treatment of sickness or injury; 5 out of 10 producers would contact a veterinarian first for a reproductive problem. About 3 out of 10 producers would contact a veterinarian first for a herd management problem; and only 1 out of 10 would contact a veterinarian first for a question on feed/nutrition.[1] A survey of dairy producers indicated they utilized a veterinarian's service about 20 times a year, 4 times the frequency of use for beef, hog, and sheep producers.[1]

Dairy producers utilize veterinary services more regularly than owners of other food and fibers species of animals for a variety of reasons. The dairy cow has more economic worth as an individual. Further, milk is a perishable product and its sale is equally perishable if the processor refuses to buy the milk because of high somatic cell counts. Veterinarians have served the dairy industry well by providing emergency service. Total animal health care is emerging and will continue to emerge for those veterinarians and producers who are inquisitive enough to solve problems.

Veterinary education at the undergraduate level is changing, as will continuing education for the practitioner; however, in viewing producer's needs and attitudes, as a profession, we have a long way to go to improve our credibility.

Graduation from any institution is often referred to as commencement. By definition, this term means the beginning, not the end, of our educational process. A veterinary college faculty must not only provide the best information presently available, we must also create a positive attitude toward endless, continuing education in its graduates.

We, as a profession, must become aware of newer and better methods. In addition, we must be able to change our deeply ingrained attitudes or techniques if that change is going to benefit our clients. Further, the way we present ourselves, the cleanliness of our equipment, the way we speak and dress, as well as our willingness to find and adopt new techniques must be continually reinforced in our clients' eyes. In making recommendations to producers, we must have sufficient information about that owner's operation to apply sound principles which we know will be of benefit. In short, we must have a thorough knowledge of what we are recommending and data to back it up so that changes made will be both workable and income generating for the client. Something to remember is, don't tell the client you care about his or her operation--show them you care.

The environment in which every animal on a dairy finds itself has seven basic components, they are:

Animal Environment	Microbial Numbers
Uterus	Sterile to Few
Maternity Barn	↓
Calf Hutch	
Super Calf Hutch	
Heifer Facility	
Dry Cow Facility	
Milking Herd Facility	Many, many organisms

At the University of Minnesota, the Veterinary Medicine-Agricultural Engineering interdisciplinary approach to environment versus disease has been studied both experimentally and clinically for over 20 years.

Every environment an animal occupies has a direct bearing on health and productivity. An adequate environment must include sufficient spacial volume per animal housed, a properly designed ventilation system, adequate eating areas, adequate resting areas, and adequate exercise areas. In addition, the whole facility must be properly maintained.

Any herd health program that does not include a thorough evaluation with subsequent correction of environmental deficiencies is not a herd health program. Evaluation of confinement units by veterinarians must include assessment of the operator's managerial ability and an examination of the animals' housed, as well as an examination of the physical plant. This exercise requires a mixture of epidemiology and immunology. In addition, primary, secondary, and continuous monitoring of the building is essential. The location of diseased animals in a building is a direct reflection on the overall design of the unit. Further, in most situations, an improperly designed unit severely compromises the manager's ability to rear healthy livestock. When young, nonimmune animals are brought into a unit, housing older animals, the potential for an acute disease outbreak immediately exists. The extent and intensity of the disease state will be further compounded by improperly designed ventilation systems. In poorly ventilated buildings, exposure of susceptible animals to recovered carriers will increase the probability of disease because of the increase in concentration of pathogenic organisms. The flow of air within a building housing animals of varying ages should always be from the younger toward the older animals. The correct placement and construction of barrier walls to minimize exposure between newly introduced animals and the older population is also very important. Extensive studies have shown a 75% reduction in disease and treatment costs in newly introduced groups of cattle if a barrier wall is properly constructed.[2]

A free-stall design for dairy cows has been researched for some time. The most satisfactory stall, we have found to date, which contributes to cow comfort and cleanliness is illustrated in the attached notes. This stall design has contributed to lower somatic cell counts by improving cow cleanliness.

In order to train dairy cows to use free stalls, it is best to have replacement animals already trained as calves to use free stalls. In like manner, heifers should be introduced to free stalls in the dry cow facility for one month prior to calving. It is becoming increasingly apparent that although supportive data has been made available for years, separate maternity units are not widely used. As a profession, we are either not communicating microbial concepts to clients, or producers are "traditional" and do not accept the method. Quite possibly both of these reasons are at play.

Initial exposure of the newborn calf to environmental organisms immediately following birth, on most dairies, is extensive. The calf in winter is stressed extensively because it is wet, and many times it is not well attended by its dam. To correct this management deficiency, the calf drier unit was designed and built. This unit has proven itself invaluable especially when maternity barns are naturally ventilated and are therefore cold in winter. Further, where exposure to high numbers of organisms is great--especially in Johnes herds--it is an ideal addition to the calf rearing program.

As a result of an interdisciplinary calf study recently completed at the University of Minnesota, a thermally insulated calf coat was developed. This coat, in conjunction with the calf drier unit, has become invaluable when calves are placed into hutches during cold weather. They are only necessary for the first 10 days of the calf's life in the hutch until calves are acclimated to cold weather and they are on an adequate diet.

Total animal health care systems require restraint units which are safe for both humans and the animals being examined. Time required to perform medical and/or surgical procedures is greatly reduced compared to that required when these procedures are done in a milking parlor, a pen or even in tie stalls. "Lockup stanchions" work well where cattle are routinely fed and where they are accustomed to being used. However, if the use of lockups is attempted where cows do not routinely use them, they are not advisable as they require great physical effort to get cows into them for restraint.

Adequate restraint, in addition to improved efficiency, also improves accuracy of diagnosis and effectiveness of treatment. The disease conditions can be detected earlier due to improved examination accuracy, and early treatment allows faster recovery. Stress on animals is also minimized by properly designed restraint facilities. In addition, restraint units must be located to allow a smooth flow of animals from the main barn to the handling unit and back to the main barn. Holding pens which are used to congregate cattle prior to entry into restraint facilities should be adjacent to feed bunks as well so that dairy cattle are not held away from feed for any extended period of time. The restraint units should also be designed for either allowing space for the mobile veterinary unit inside, or at the very least, close proximity for the veterinary unit to the cattle working area.

Total animal health care programs have a further advantage which soon becomes apparent. As a result of scheduled visits and organization of the producer's operation, the decreased incidence of disease markedly decreases antibiotic use. Antibiotic usage in calves in this practice has been decreased on all operations over 90%. Another distinct advantage is that sensitivities to more common antibiotics return. This is advantageous because less expensive medications are required to treat disease. Further, antibiotic residues are also eliminated.

As a result of carrying fewer medications and less of them--because fewer disease outbreaks occur--a smaller veterinary unit is adequate. If we are going to tell our clients to become more efficient, as veterinarians, we must be more efficient ourselves. One client asked my why I didn't drive a larger unit. My reply was, "In order to keep costs down and not increase call charges, I drive a small unit."

Multiveterinarian practices are now commonplace. The trend has been towards species specialization. The future in dairy practice is going to be even further specialized where one or more veterinarians handle milking equipment and procedures, one or more veterinarians are responsible for nutrition, and one or more veterinarians consult with clients on environments and facilities. Practices usually have problems when one member is off doing "herd work" and the rest of the practice members are "taking calls." If all veterinarians are involved, communication is improved and miscommunication and misunderstandings are less likely to occur. Further, it is readily apparent that when seen by only two eyes, many aspects of a client's operation may be missed.

The following attached publications are offered to further assist conference participants in disease control and to enhance understanding of sound building recommendations.

References

1) Wise, K. U.S. Market for food animal veterinary medical service. JAVMA 1987, 1530-1533.

2) Anderson, J.F. Placement and construction of barrier walls. Unpublished Data.

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FREE-STALL HOUSING FOR DAIRY CATTLE

Donald W. Bates
Professor and Extension Agricultural Engineer

John F. Anderson
Professor of Large Animal Clinical Sciences

Figure 1. This naturally ventilated, slat-floor, free-stall dairy barn located in southern Minnesota is 80 x 200 feet and contains 206 stalls. There is a continuous, 16-inch-wide, uncovered open ridge at the roof peak together with 4-foot-high vertically operated wall vents. The ridge and vents run the full length of the building on both sides. Wall vents are manually controlled with winches. Cows are milked in a double-eight herringbone parlor (figure 8). There is a liquid manure tank 85 x 200 x 10 feet beneath the barn with storage capacity for about eight months.

Agricultural Extension Service **University of Minnesota**

An investment in a new dairy barn is one you're likely to make only once or twice in your dairy career. Before spending any money or signing any contracts, investigate all your options. Careful planning will ensure the greatest value for your investment dollar. But do not make your choice on cost alone; be sure to get a building that meets all your needs.

A practical way to house dairy cattle is with free-stall barns. They are often used for herds of 60 cows or more and are generally used for herds larger than 80 cows.

Free-stalls were first used to replace manure packs in loose-housing barns. Reduced bedding needs and improved cow cleanliness resulted. Today, free-stall housing can include a milking parlor and feed-handling system. It can also include a system for what may be one of your most difficult problems, handling and disposing of manure.

Free-stall barns can be cold (open and uninsulated with natural air movement providing ventilation and the barn temperature approximating the outside temperature) as shown in figure 1, or warm (completely insulated and mechanically ventilated) as shown in figure 2. Most new free-stall barns are now of the cold type because construction costs are lower and the cost of operating a mechanical ventilation system is avoided. However, cold free-stall housing is not generally recommended for northern Minnesota, primarily because of difficulties in dealing with frozen manure (figure 3).

Figure 2. This is a warm, mechanically ventilated, free-stall barn with slatted alleys and a mechanical bunk for feeding roughage. Minimum labor is needed for feeding and manure handling. Note the cleanliness of the animals. ▼

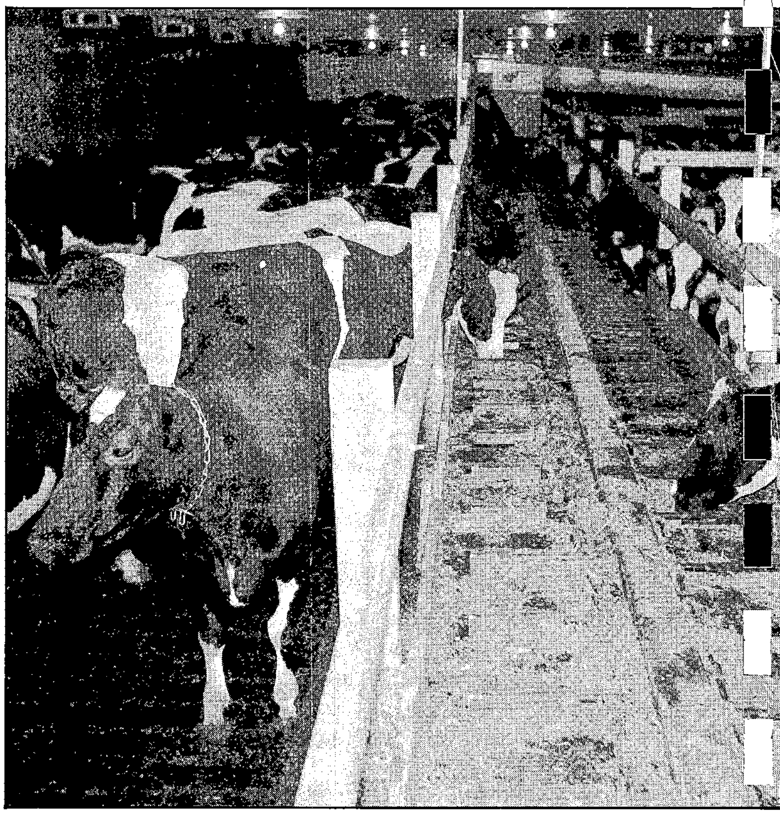


Figure 3. Frozen manure problems in this cold, free-stall barn, used in Itasca County for more than 20 years, have been dealt with in subzero weather by scraping the alleys twice a day using a heavy tractor having a specially constructed blade. Herd production is high because of excellent management. Cold, free-stall systems are not generally successful in northern Minnesota. ▶

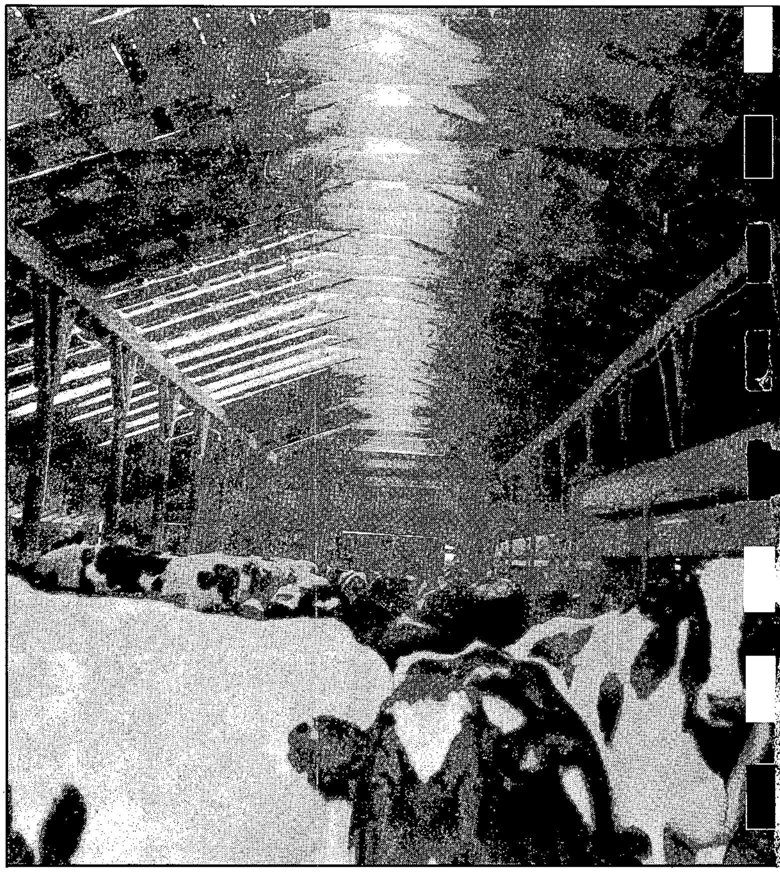
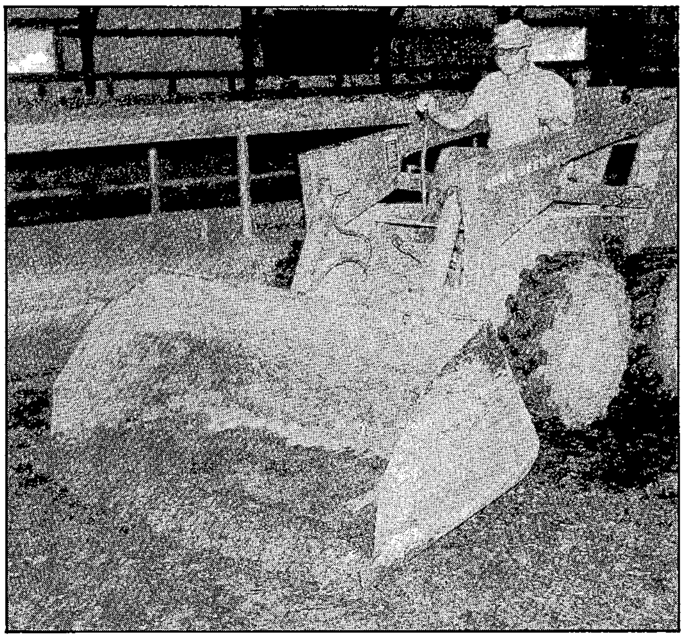


Figure 4. A skid-steer tractor is easily maneuverable for cleaning solid manure alleys. It is important to have a bucket which can be held down hydraulically to remove frozen manure. ▼



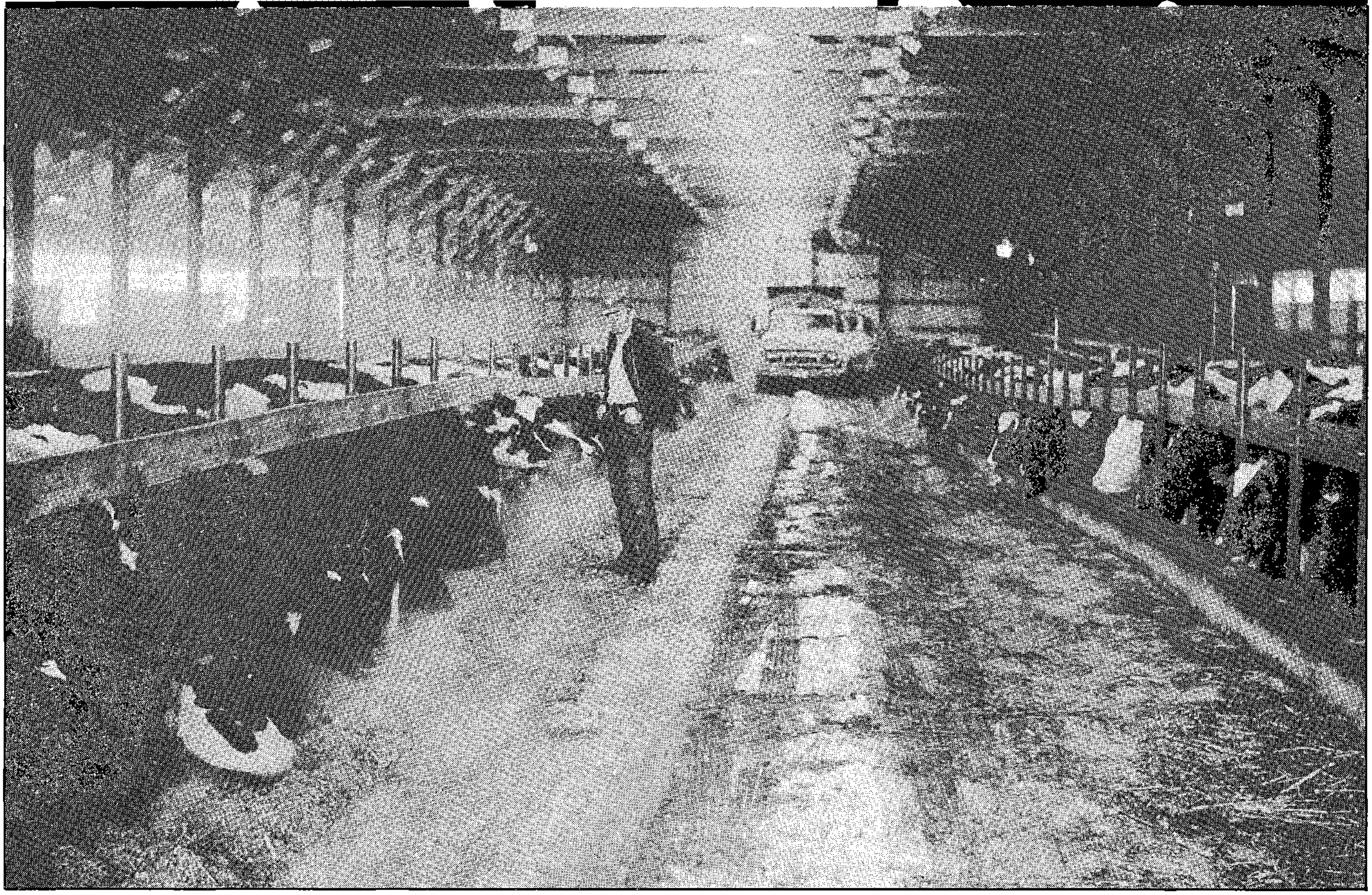


Figure 5. In this large, cold, free-stall dairy barn, roughage is fed with a truck from a central feed alley. This method is particularly well-suited to large operations where much roughage is preserved in horizontal silos. Ventilation is accomplished through an open ridge in combination with sidewall openings.

WASTE REMOVAL

Access to free-stalls is from an alley behind them. With properly designed stalls, most excrement is deposited in the alley. How you plan to handle this waste will largely dictate the general barn design. If the alley floors are solid, manure and urine must be scraped at least daily with either an automatic scraper or with a suitable vehicle (figure 4).

Waste can be deposited directly into a manure spreader by the scraping vehicle for daily hauling. Daily hauling is often difficult depending on weather, field, and crop conditions and is also time consuming. For these reasons, most dairy farmers opt for long-term storage when building new facilities. Choices for long-term storage include an earthen storage pit with a transfer pump or gravity system, slat floors with manure storage beneath, above ground storage in a round tank or silo with a transfer pump, or stacking.

All solid-floor systems require some means by which the manure can be moved to one or more collection points. A common problem is that the steel blade on the scraping vehicle (figure 4) will usually polish what was once an acceptably rough surface in five years or less. Serious injuries to the cows are often the result of such polishing. Injuries resulting in extensive treatment and reduced production are often followed by chronic arthritic conditions which can shorten a cow's longevity in the herd as well. Heat detection becomes increasingly difficult because cows soon learn that movement means slipping on the floor and subsequent pain.

Slatted alleys eliminate the scraping and collection operations because waste passes directly through the slat openings into storage beneath (figure 1). It is removed periodically, depending on the capacity of the storage. Further, there is little manure build-up on the floor, and cows' feet remain comparatively clean. This is advantageous when cows move directly into the milking parlor from a slatted alley (which can double as a holding area), because the amount of manure tracked into the milking parlor is substantially reduced.

Slatted alleys may increase the initial cost of the building, but they eliminate scraping and the cost of purchasing and maintaining a scraping unit. While scraping alleys may appear to be a minor task, it still takes time and effort. During the "busy season" it's easily overlooked, and undesirable conditions may result. When this occurs, coliform mastitis is often the costly outcome.

An automatic scraping system keeps solid alleys relatively clean. Also, it is less likely to make the floors slippery than is daily scraping. Foot and leg injuries may result from contact with the scraper blades or paddles, however. In naturally ventilated buildings, manure often freezes on the floor. There is then a tendency to close the building to prevent freezing, but doing so will create a hostile environment for the housed animals. Serious respiratory disease will often result.

FEEDING

All, or nearly all, feeding is generally done within the housing unit or in an attached feeding structure. Roughage may be delivered by a conveying system or by a truck or tractor-drawn wagon (figure 5).

Figure 6. Heat detection is sometimes thought to be a simple matter in a free-stall barn where cows intermingle. However, time must be set aside for observation. In a long barn, unless a catwalk (figure 1) or an access alley (figure 7) is provided, moving among the animals to identify an individual animal may be difficult.

Although it was once common to feed grain in the milking parlor, this practice is now obsolete because high-producing cows cannot eat sufficient amounts in the time allotted. Furthermore, grain produces dust, and grain spilled on the floor causes etching of the concrete.

In the housing unit, grain is usually fed to groups divided on the basis of production. Individual animals may be fed extra grain from various types of electronically operated devices.

COMMON DESIGN CRITERIA

A cow does not consistently occupy the same stall, nor do all cows lie down at the same time. Consequently, it is common practice to keep about 30 percent more cows in the housing unit than there are stalls. Some cows will not use free-stalls but rather lie down in the alley. Remove such cows from the herd.

Heat detection requires careful observation and is usually no easier to accomplish than in a stall barn. In a long barn it is often difficult to identify a cow in heat (figure 6) because the herdsman may be unable to move quickly among the cows. When possible, turn cows out daily and observe them for at least 30 minutes. Providing a catwalk permits observation of the animals without walking among them and is recommended in naturally ventilated barns having sufficient headroom (figure 1). By increasing the barn width and building alleys in front of the stalls (figure 7), the operator can have access to the herd without walking among the animals.

Free-stall barns are built with two, three, four, or even six alleys. A popular width is 40 to 42 feet with a row of stalls facing each of the long walls. A feedbunk of adequate length is then built on the center line. At least 2 feet 4 inches of bunk space is needed for each cow if all animals are to be fed at the same time. If feed is always available, 6 inches per cow is satisfactory. The feed bunk does not require all of the barn length. Remaining space is used for cross alleys and one row of stalls which may be at either end of the bunk, depending on the interior arrangement. Wider buildings having more rows of stalls often present special problems in both environmental control and manure handling.

HOLDING AREA

Twelve to 15 square feet of the holding area is needed per animal. With proper planning, efficient use of barn space can be made by using a section of the slatted alley adjacent to the milking parlor as a holding area.

A fundamental principle, regardless of type of free-stall housing, is to have cows step directly into the milking parlor from the holding area. In addition, cow movement into the parlor is improved when they can see activity there while waiting. An overhead garage door can be used to separate a cold holding area from the milking parlor (figure 8). When a heated holding area is connected to a cold housing system, the units need to be separated by two garage doors (figure 9). In this case, the

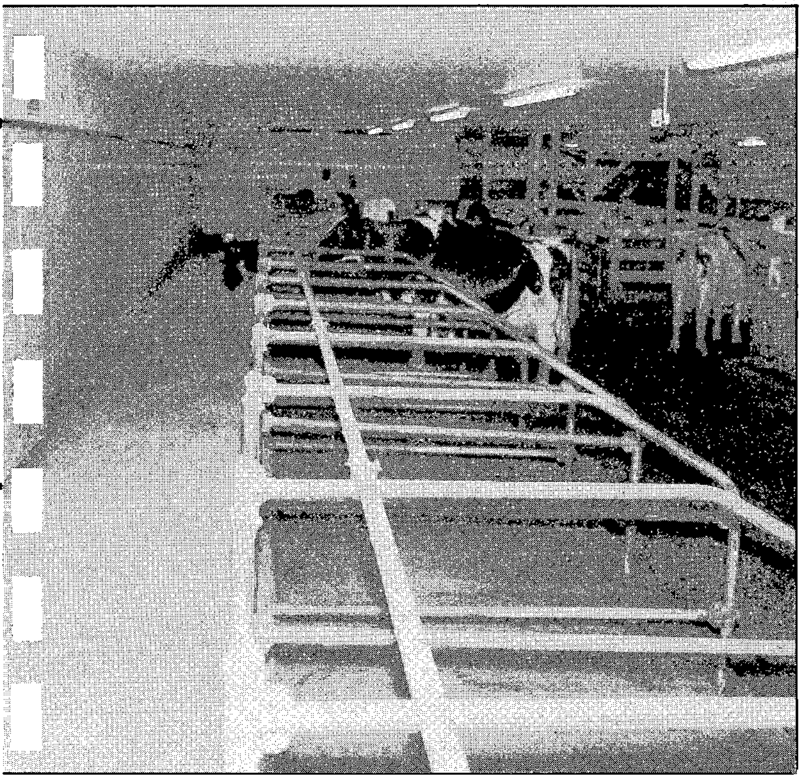


Figure 7. This warm, slat-floor, free-stall barn has 6-foot-long stalls with fronts similar to regular tie stalls. The alley in front of the stalls, which extends around the entire barn, can be used to observe the animals without walking among them. Since this alley is always clean it encourages operator use and observation.

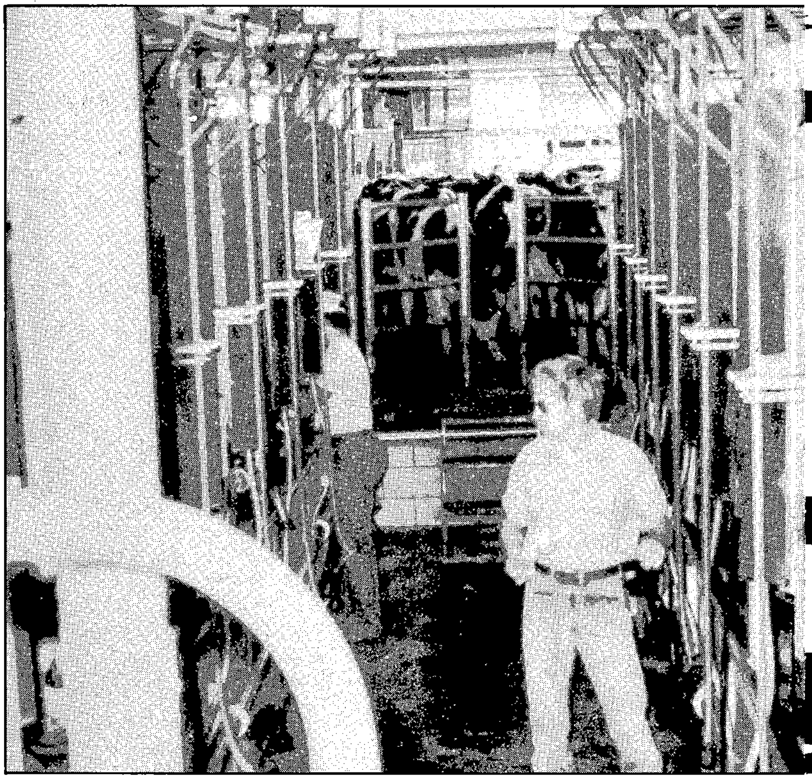


Figure 8. In the background, cows are waiting to enter the double-eight herringbone parlor serving the barn shown in figure 1. The holding area is cold. An overhead door separates the milking and holding area and is open only for cow access at milking time. An electric crowding gate is used to move the animals forward.

Figure 9. This warm holding area serves a cold, free-stall barn. It has capacity for about one-half of the milking herd. During milking the overhead door to the milking parlor is open. The door separating the holding area from the housing area is always closed except for animal movement.

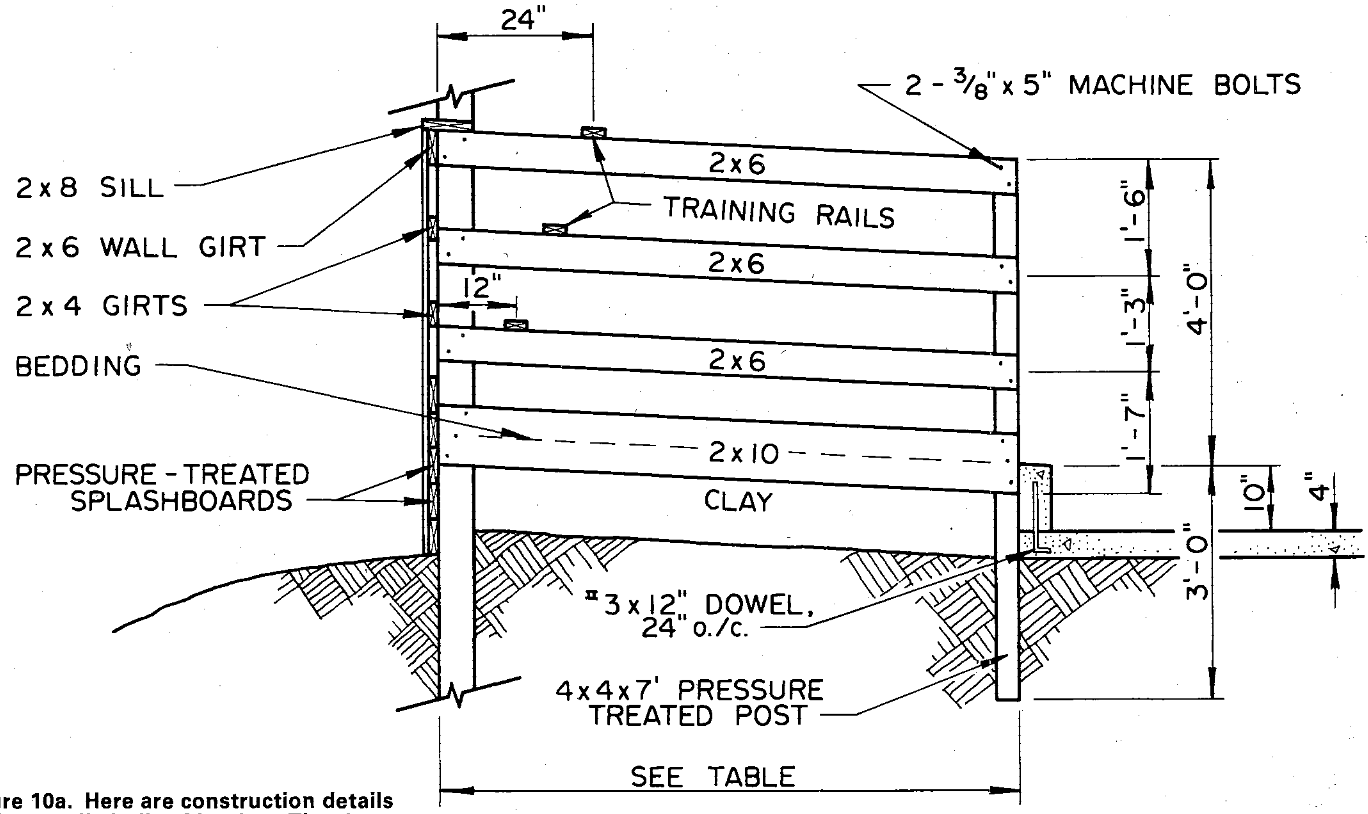


Figure 10a. Here are construction details for free-stalls built of lumber. The three training rails at the front prevent the cows from standing with their hind feet in the stall, but permit them to lie down comfortably. A bottom partition rail set two inches into the earth floor will prevent the cows from digging holes.

FREE STALL DETAIL

holding area must be insulated and mechanically ventilated. Hold cows for no more than two hours at each milking and for only one hour when milking is three times daily.

In many milking parlors, half the cows must cross the milking parlor at one end. This should be at the exit.

STALL SIZE

Free-stalls must be wide enough to be comfortable, but not wide enough for cows to turn around and contaminate the stall's front end. Stalls should be long enough to allow cows to lie with their udders protected, but not so far forward that they can deposit manure onto the stall. Use 4-foot-high side partitions and 5-foot-high front partitions so that the cows cannot reach their heads over the top.

Recommended dimensions for free-stalls are measured center to center of 2-inch-thick dividers. Stall lengths are measured from front of stall to alley side curb.

Table 1. Free stall dimensions*

Age	Width	Length
Calves		
3-4 mo	2′-0″	4′-6″
5-8 mo	2′-6″	5′-0″
Heifers		
9-12 mo	3′-0″	5′-6″
13-15 mo	3′-6″	6′-6″
16-24 mo	3′-6″	7′-0″
Cows (average herd weight)		
1,000 lb	3′-6″	6′-10″
1,200 lb	3′-9″	7′-0″
1,400 lb	4′-0″	7′-0″
1,600 lb	4′-0″	7′-6″

*Midwest Plan Service, *Dairy Housing and Equipment Handbook*, 1985

STALL DESIGN

As cows are getting up, they must be forced to move back so that droppings are deposited onto the alley. A neck board or cable placed across the top of each stall and spaced about 2 feet from the front will usually force them to stand back. However, cows that get up front feet first may get caught beneath and can damage the neck bar and injure themselves. Three horizontal bars at the front (figure 10) permit an animal to lie down comfortably, but force it to move back when getting up.

For economy, free-stall floors may be of earth. Well-compacted clay is preferable to other soil materials (figure 11). However, cows often make deep holes in earthen floors (figure 12). As a consequence they may become caught under the stall partitions and injure their hips and

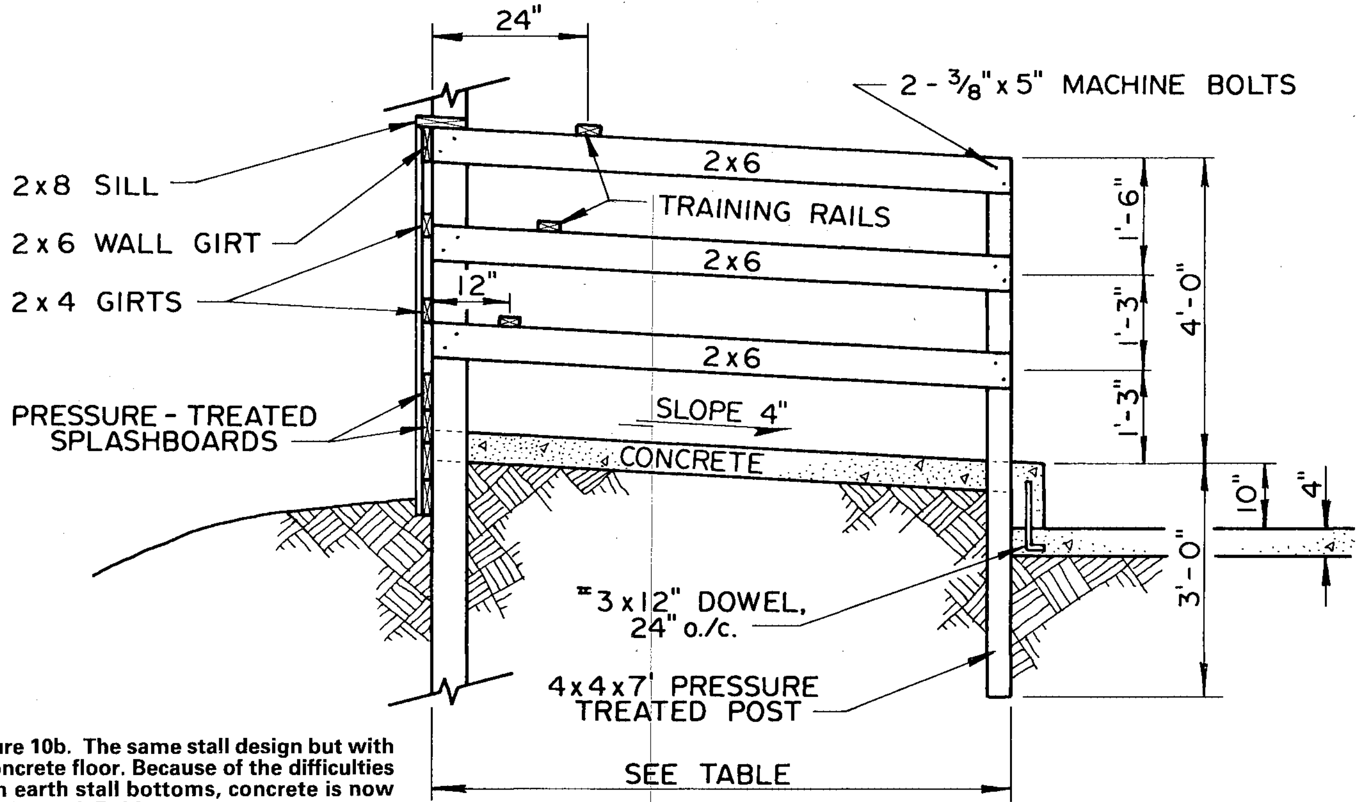


Figure 10b. The same stall design but with a concrete floor. Because of the difficulties with earth stall bottoms, concrete is now widely used. Rubber mats may or may not be used depending upon bedding practices.

FREE STALL DETAIL

1. These free-stalls have compacted clay floors. They are r~d yearly and perform well. The curb is 10 inches high, :ommended for cold, free-stall barns where manure is h a tractor.

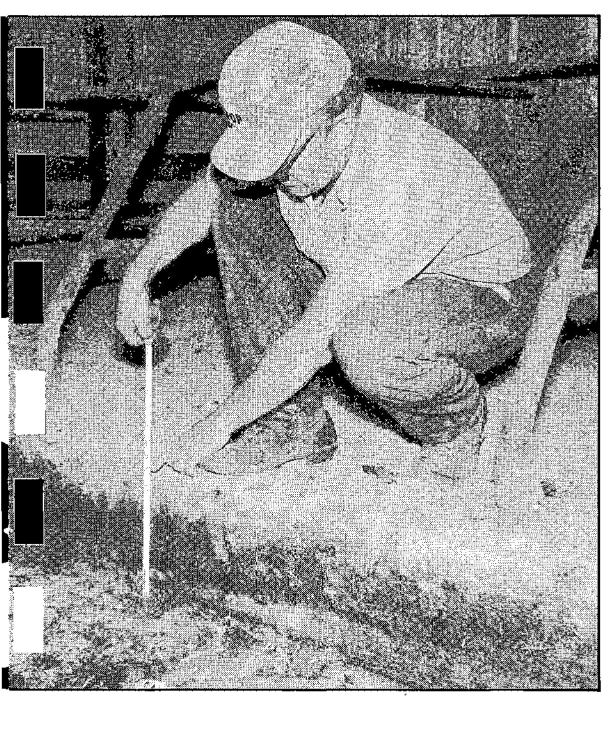
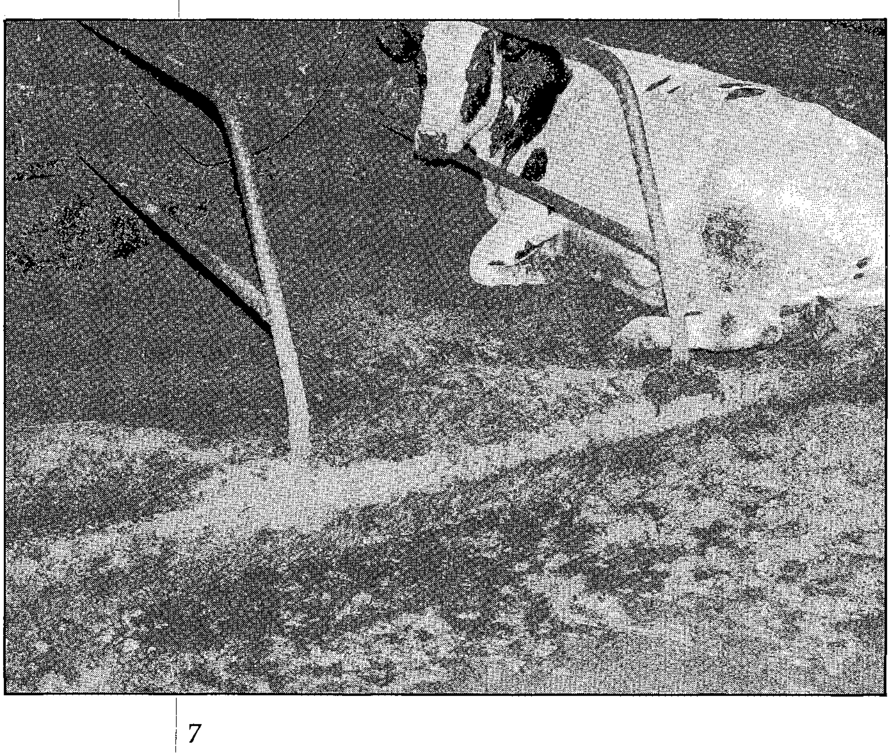


Figure 12. The deep depressions in the earth floors of this warm, free-stall barn are typical of those that develop quickly where light soil is used. Because of such problems concrete stall bottoms are in common use.



legs. Bloat also may result if the cow is down and unable to rise. While it is easy to replace earth periodically, the job is time-consuming and usually doesn't get done. Cows' digging in earth-stall surfaces can be reduced by placing a 2- x 10-inch bedding board on edge between each stall with the lower edge buried about 2 inches into the earth (figure 10b). Earth stalls are not recommended when a liquid manure system is used.

Concrete floors may increase construction cost, but they eliminate the problems of earth stalls. Cows prefer lying on earth rather than on concrete or even rubber mats, so it is important that all stall surfaces be constructed of the same material. Rubber mats are now commonly used for supposed added cow comfort. Approximately the same amount of bedding is needed regardless of the stall surface. A slope of 3 to 4 inches from the front to the back of the stall is recommended, (figure 10b).

With manure scrape alleys, a curb height of 10 to 12 inches (figure 11) is recommended to prevent manure from being carried up onto the stall platforms during scraping. A curb height of 6 to 8 inches is recommended in a barn with slat floors because of the tendency for manure to build up immediately behind the curb. This is particularly true in cold units during freezing weather.

A frost-free water supply is required in cold buildings. Heated waterers are commonly used. Provide one compartment or about 2 feet of water tank perimeter for 20 cows. Use at least two waterer locations for each production group of cows. When cows are fed outside, locate waterers outside also.

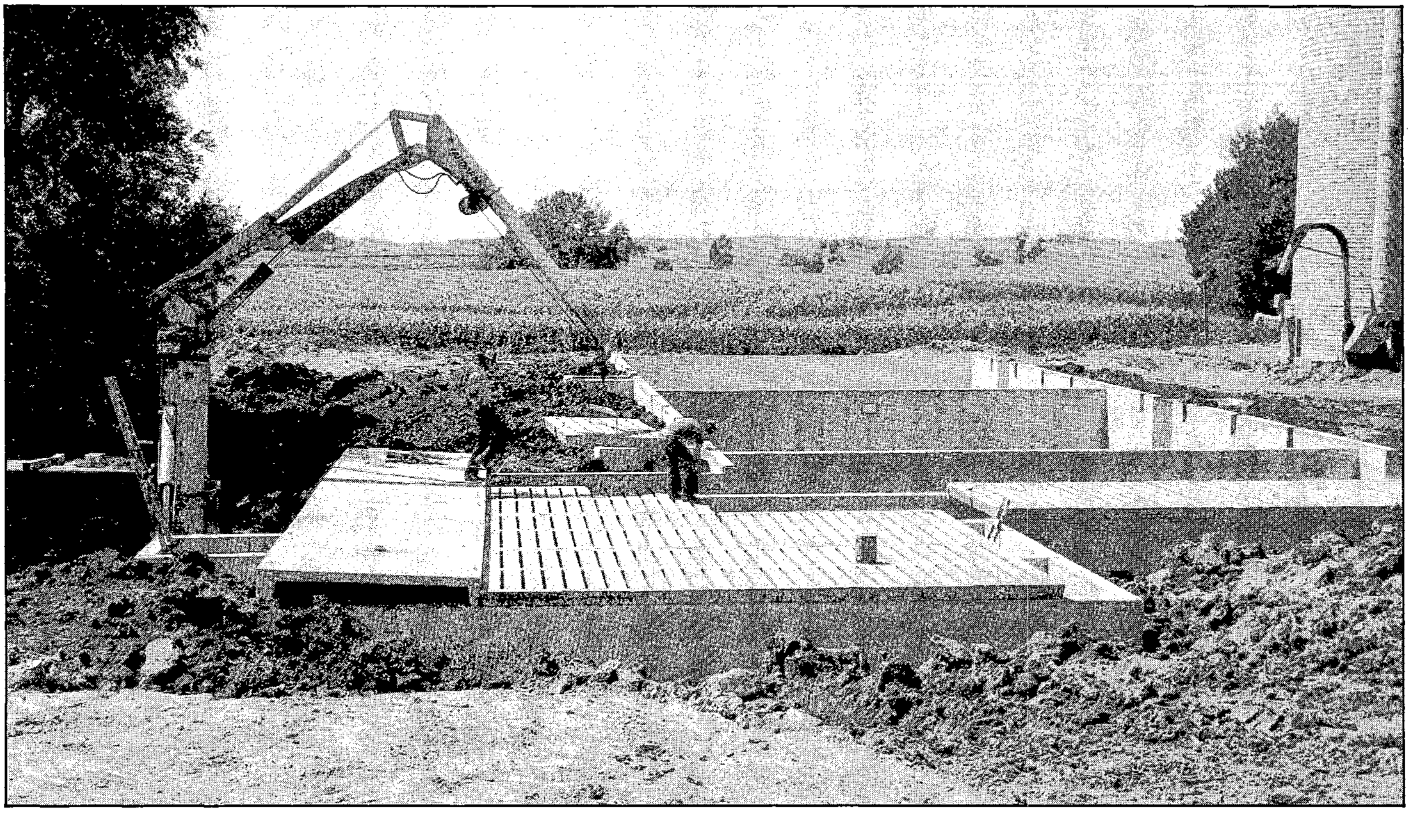
SLAT FLOOR DESIGN

Slatted alleys through which manure falls to storage beneath are commonly used in free-stall barns (figures 1 and 2). Since manure is moved through the floor openings by animal traffic, this traffic must be concentrated by limiting alley width. Usually all, or nearly all, roughage is fed in the barn. Alleys adjacent to feed bunks should be 9 or 10 feet wide.

Alleys used for cow traffic only—such as between rows of free-stalls—need only be wide enough to permit free movement of cows in and out of the stalls. A 6-foot width is sufficient, but it may be practical to make all alleys the same width—9 feet—to accommodate possible vehicular traffic, to occasionally scrape the slats, to distribute bedding, and for structural design.

Concrete slats with steel reinforcing are commonly used. They may be either individual or gang slats. Individual slats are lighter and easier to handle, but they must be mortared at each end to hold them in place. Gang slats are cast in a grid and are connected at each end and at the center. Because of their weight, special equipment is needed to handle them (figure 13), but their weight eliminates the need for mortaring the slats in place. A slat width of either 6 or 8 inches is recommended with a slot

Figure 13. Gang slats for the floor of this cold, slat-floor, free-stall barn are being moved into place. Because of their weight, often about 1,800 pounds, they remain in place without mechanical connection. The manure pit has three compartments and individual agitation and pumpout stations. An alternative is to extend the pit making it wider than the barn and agitate through openings in the cover. Partitions can then be omitted but support for the wall of the barn which would otherwise rest on the manure tank wall must be provided.



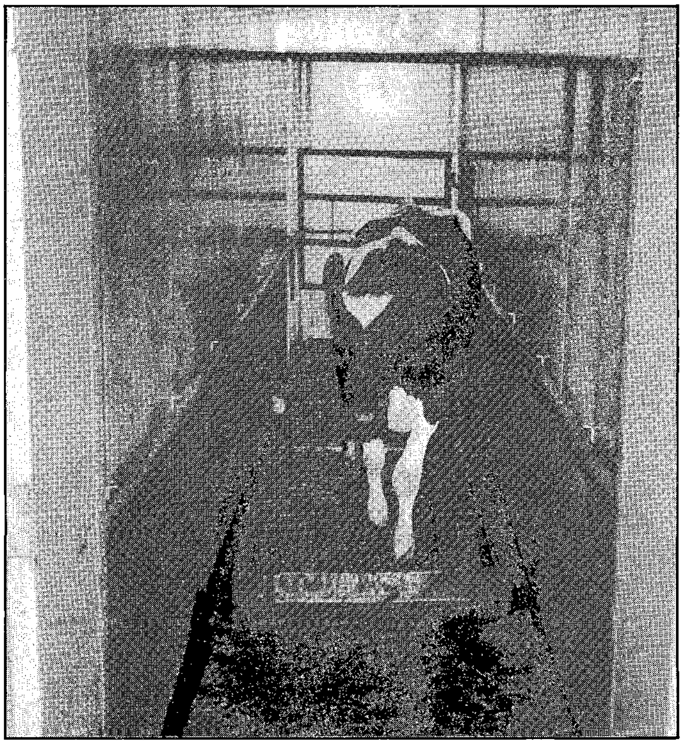


Figure 14. Foot bath containing a copper sulfate solution effectively treats hoof rot. Make the tank long enough, about 6 feet, so the cow must step in with all four feet. Solution depth should be about 3 inches. Because of manure accumulation, the solution should be changed weekly.

width of 1-3/4 or 2 inches. This spacing is satisfactory for calves as well as cows. Slats are usually placed parallel to free-stall curbs. It is important to allow a full slot opening immediately behind the stall curb to reduce manure build-up behind the stalls.

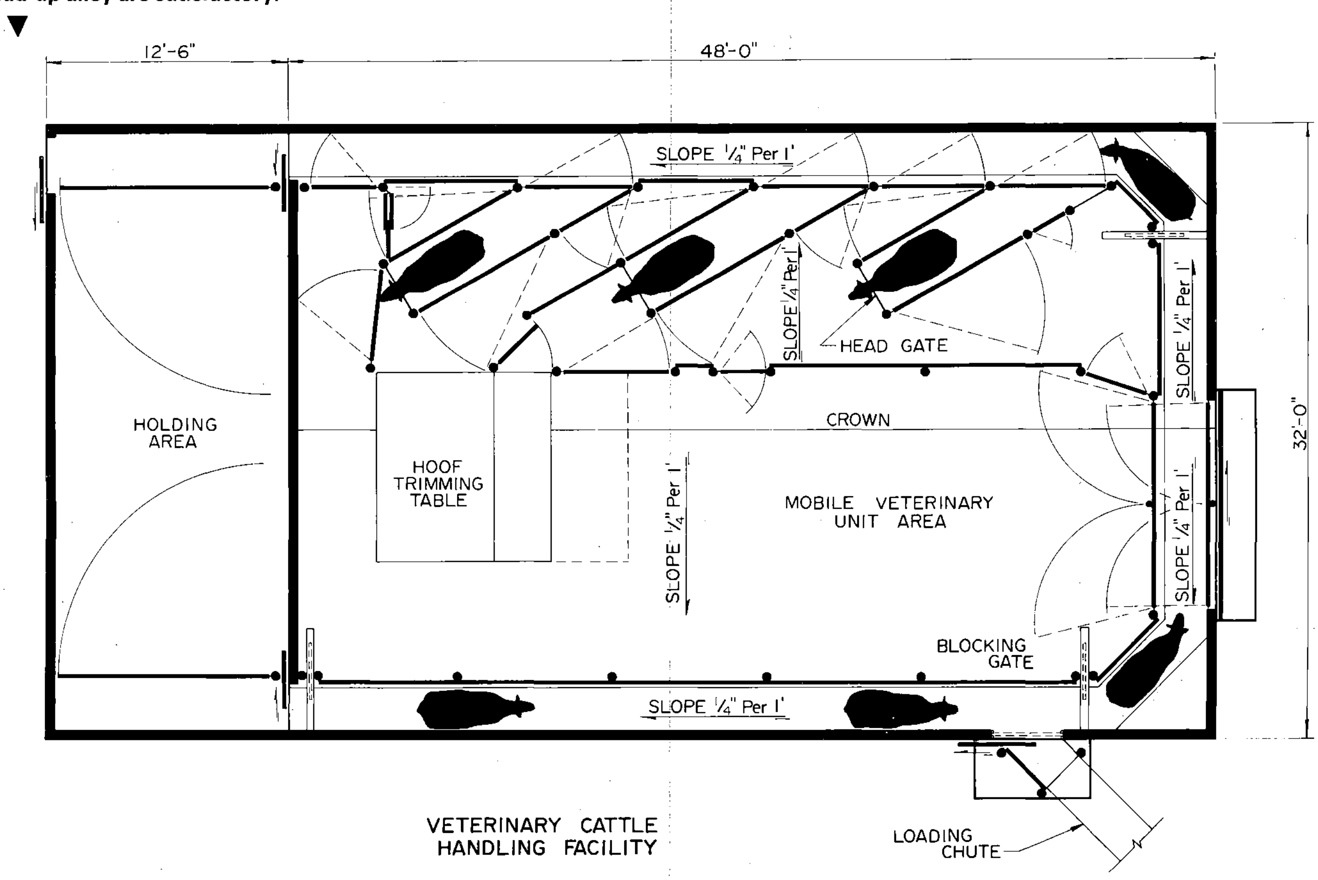
Diseases of the hoof may develop with either slat or solid floors for a variety of reasons. We recommend that animals walk twice a day through a copper sulfate foot bath (figure 14). For mild cases, a solution of 3 pounds copper sulfate to 100 pounds, 12.5 gallons, of water is satisfactory. For severe cases, 5 pounds of copper sulfate per 100 pounds of water is recommended. Check with your veterinarian before starting this treatment.

HANDLING AND TREATMENT

A permanent means of restraining cattle for medical examinations, treatment, hoof trimming, artificial insemination, and other procedures is needed. Some medical work is often done in milking parlors, but this procedure is not recommended. Milking parlors are not designed for this purpose and using them for sorting and animal restraint is often inconvenient and hazardous for both the animals and the persons performing the treatment. Also, cows may become reticent to enter the milking parlor at milking time for fear of repeat treatment.

Provide some type of separate restraint and examining space. This may range from a few stanchions to a specially designed building for larger herds (figures 15 and 16).

Figure 15. Basic floor plan of a handling and treatment building for a large herd showing movement of cows. Animals walk through the headgates and can be returned directly to the barn or be diverted to the hoof trimming table. Restraint stalls placed at an angle conserve space yet allow access from both sides and reduce animal hesitation. For a smaller herd, one or two restraint stalls with a suitable holding area and lead-up alley are satisfactory.



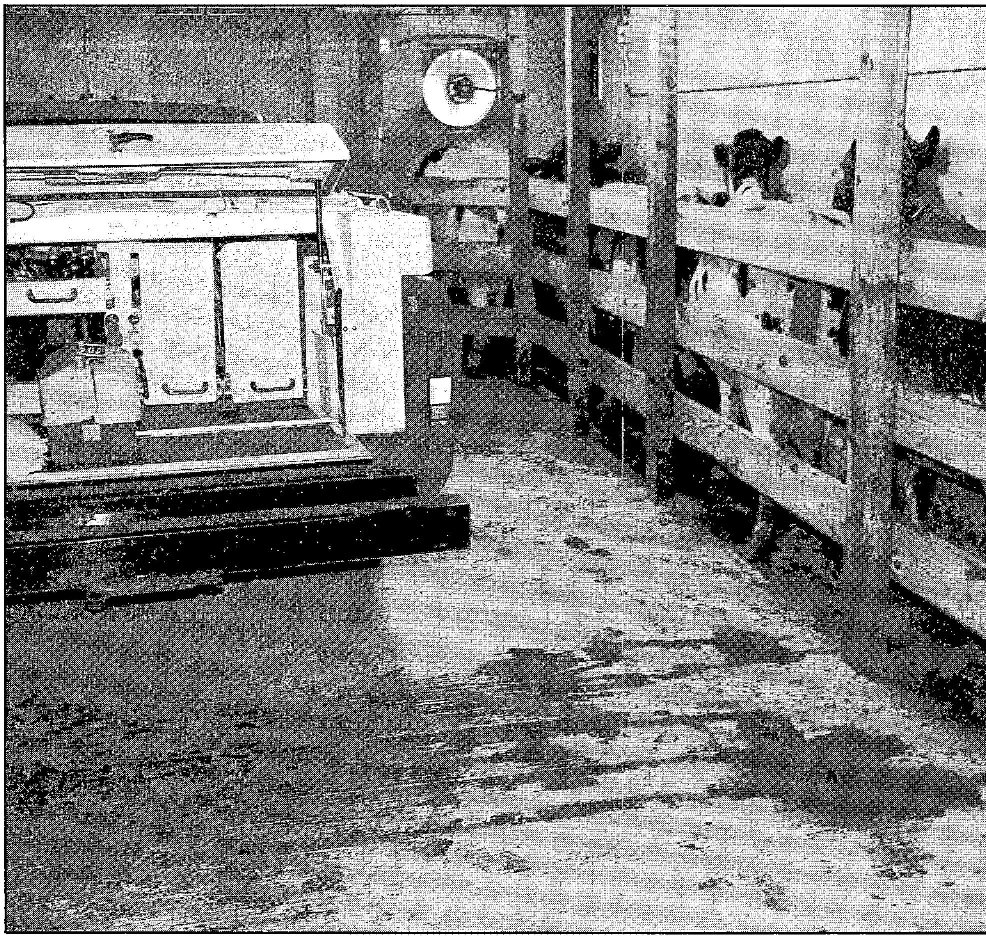


Figure 16. Cows move freely through the 28-inch wide lead-up alley placed around the outside of a building designed from figure 15. The alley floors also serve as gutters for flushing water which flows to the liquid manure tank beneath the main barn. The veterinarian's truck is backed into the building for convenient access to medical and surgical supplies.

Considerations in planning restraint facilities are:

1. Have a smooth flow of cow traffic with maximum safety to both people and cattle. Animals should not require physical force to enter a restraint area or chute.
2. Provide convenient facilities for examining and treating cows and for trimming hooves.
3. Include space for a veterinarian's truck. Being close to the treatment area reduces time spent in preparing and administering treatments.
4. Make the area easy to clean; otherwise it is not likely to be maintained in a sanitary condition.
5. Provide suitable heating and ventilation.

A systematic way of handling animals reduces the time required by the veterinarian to perform treatments and your time in collecting the animals and in record keeping. Animals will consistently be easier to handle.

MATERNITY AREA

A clean maternity pen is essential to the health of both the calf being born and the cow giving birth (figure 17). Provide separate, well managed maternity pens numbering one for about 25 cows in the herd. Calves born in free-stalls often are ejected onto a manure-covered alley and are likely to swallow manure before they receive colostrum. Absorption of colostral antibodies is then either reduced or prevented, rendering the calf defenseless against disease-causing organisms in the environment. Furthermore, large quantities of bacteria readily enter the young calf's mouth or navel thereby causing bacterial disease. Post partum metritis often is caused by unsanitary calving conditions. Whether calving takes place in the free-stall or in a filthy box stall, the results are likely to be the same. Maternity pens should be cleaned, washed, and disinfected between calvings to prevent disease in both the calf and its dam.

ENVIRONMENTAL CONTROL

Free-stall dairy barns may be either cold, usually uninsulated and always naturally ventilated (figures 1, 3, and 5), or warm, insulated, and mechanically ventilated (figures 2 and 7).

Insulation

Adequate wall and ceiling insulation is essential in maintaining a satisfactory environment in warm buildings. Walls should have an R-value of at least 14, and ceilings should have an R-value of 23 or more. Even with this amount of insulation, some supplemental heat may be necessary for moisture control. This is because of the greater space per animal housed compared to a stall barn and also because of the shifting animal population within the building during milking. All insulation must be protected with a tight vapor barrier installed on the warm side. Because of the controlled inside temperature, the

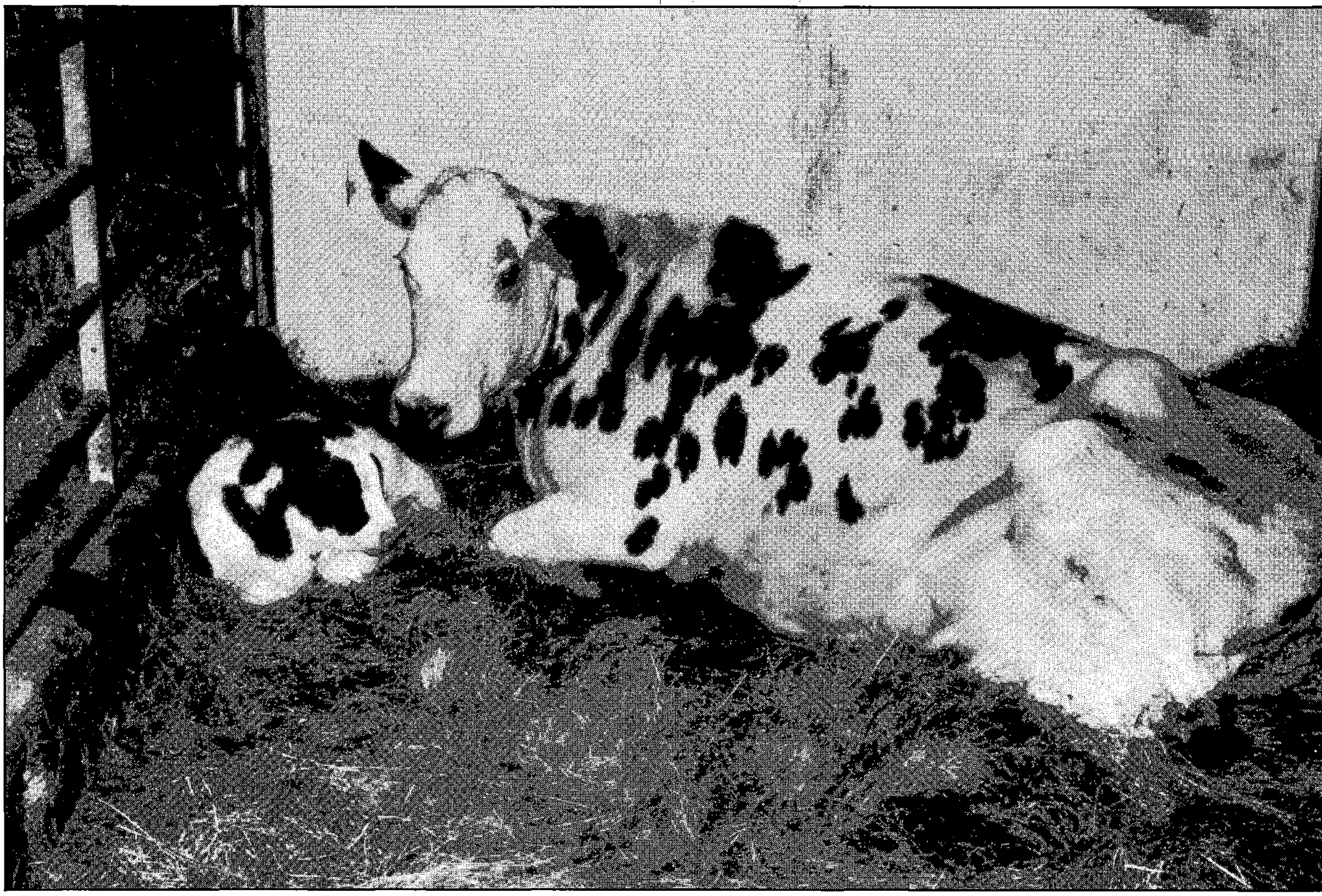


Figure 17. A clean, well-bedded box stall is essential for the health of both the cow and the calf.

problem of frozen manure experienced in naturally ventilated buildings is eliminated.

The use of many windows is not recommended. They permit heat gain in summer and heat loss in winter. Some windows are of benefit for outside observation. Never consider windows as part of the ventilation system.

Detailed planning recommendations are given in *How to Plan a Mechanical Ventilation System for the Dairy Barn*, AG-BU-1314 (M-128).

NATURAL VENTILATION

The cold, free-stall housing unit is primarily a shell to protect the animals from the weather. During winter the inside temperature must approximate the outside temperature (be no more than about 10°F above) if satisfactory environmental conditions are to be maintained. Naturally ventilated free-stall barns are now in common use because construction costs are lower and the cost of operating mechanical ventilation is eliminated. They may present a severe problem with frozen manure, however, particularly in northern Minnesota (figure 3).

Allow sufficent air exchange to prevent fogging and condensation or frost beneath the roof in winter, even though the manure is more likely to freeze. To prevent manure freezing, dairymen sometimes restrict air movement to such an extent that the moisture given off by the animals cannot escape. As a consequence, conditions develop which contribute to pneumonia, coliform mastitis,

Figure 18. Typical slat-floor appearance in a cold, free-stall barn during winter. Frozen manure will quickly work through when weather moderates. ▼

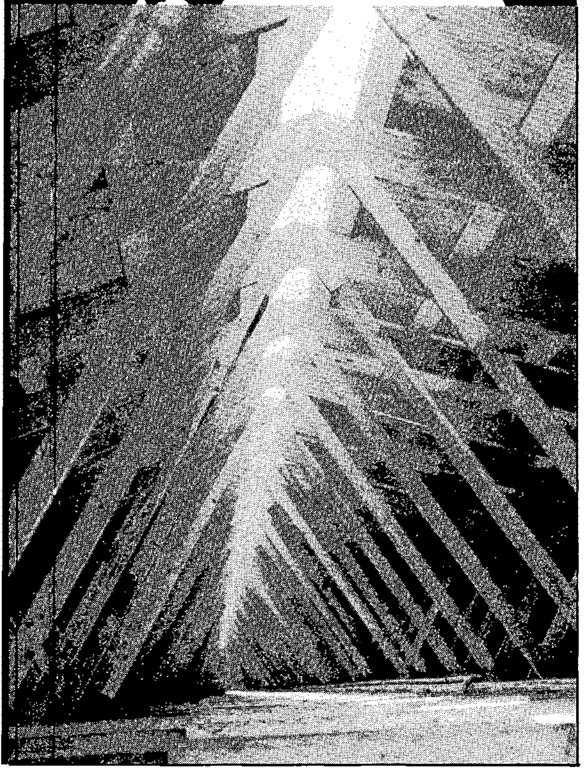


Figure 19. Cold, free-stall barns should have an unrestricted open ridge 2 inches in width for each 10 feet of barn width, thus 8 inches for a barn 40 feet wide.

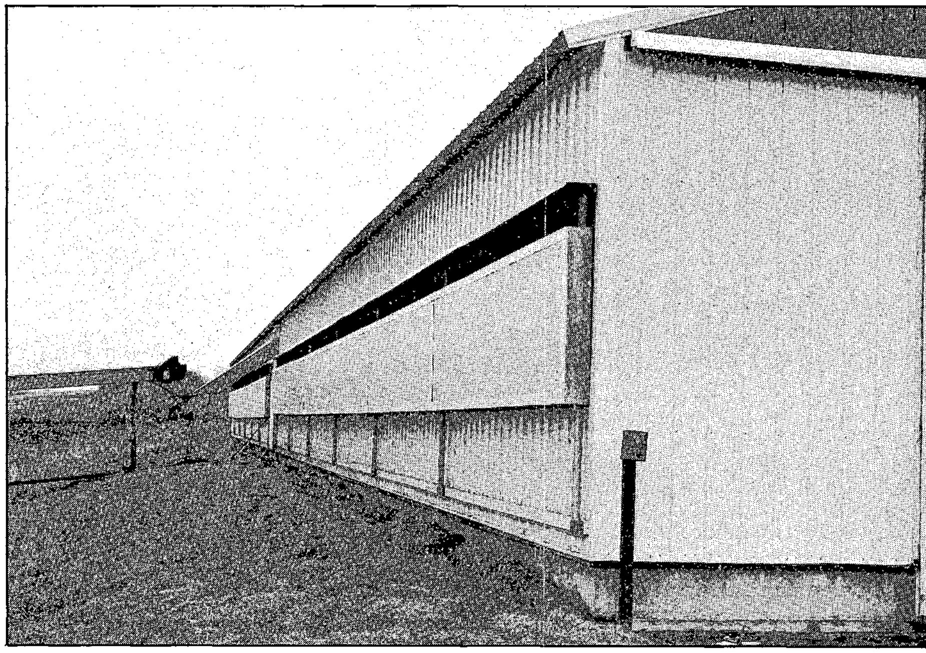


Figure 20. Vertically operated, 4-foot-high drop-type vents are used on this barn, also shown in figure 1. Regulations must be made according to weather conditions, often several times a day.

and other health problems. In addition, this moisture may damage the building.

In solid floor barns, manure is generally scraped daily but twice daily scraping is often practiced in cold weather to reduce freezing problems (figure 3). Some buildup of frozen manure on slat floors can be expected (figure 18).

A continuous open ridge together with suitable wall openings is recommended (figures 19 and 20). Make the ridge opening 2 inches wide for each 10 feet of building width. Thus, for a 40-foot wide building the ridge opening would be 8 inches. Do not construct an elevated cover over the open ridge for rain and snow protection. Such a cover inhibits airflow and can result in more snow or rain entry than would an unprotected opening. When a severe downdraft problem is caused by adjacent structures on a restricted farmstead, it may be necessary to close a short length of the ridge opening. This will encourage condensation on the roof beneath the closed portion of the open ridge, however.

Adjustable, four-foot-high sidewall openings are needed the full length of both long walls in closed buildings and in the closed side of three-sided buildings. These ventilation openings can be pivot doors; top-hinged doors; or plastic-covered, vertically operated units controlled by a winch (figure 20). Put the lower edge of the opening about 4 feet above the floor for good airflow at the cow level. Build the vent doors to open fully for maximum airflow. Adjustment must be done manually and often several times a day depending on weather conditions.

A sidewall height of 10 feet is satisfactory for ventilation. Higher sidewalls are unnecessary unless required for maneuvering equipment or installing a feed-handling system. A roof slope of 4/12 is recommended for sufficient airflow out of the open ridge.

SITE SELECTION

Many farmsteads are quite restricted and there is often inadequate space for new buildings. Do not crowd buildings together. Alternatives should include earth moving to expand the present building site or relocation on a clean piece of ground. Trees, buildings, tower silos, and grain bins change airflow patterns and may cause drafts in open-sided buildings and downdrafts through open ridges. Locate naturally ventilated buildings at least 50 feet in any direction from other structures and from trees. Choose an unobstructed area on high ground when possible. Windbreak fences can often be used to reduce draft conditions. Trees or windbreak fences affect air movement downwind for five to ten times their height. Building orientation affects the performance of a natural ventilation system. Locate buildings so that prevailing winter and summer winds are perpendicular to the long axis. An east-west placement of open-front buildings is best for winter wind control and wind penetration and for summer cooling. Airflow should always be from the younger toward the older animals. In naturally ventilated buildings housing young stock, house the younger animals in the end of the unit toward the prevailing wind.

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M-128 Revised 1982

HOW TO PLAN A MECHANICAL VENTILATION SYSTEM FOR THE DAIRY BARN

Donald W. Bates, professor and extension agricultural engineer
John F. Anderson, professor of large animal clinical sciences

UNIVERSITY OF MINNESOTA AGRICULTURAL EXTENSION SERVICE

A mechanical ventilation system must be correctly planned to be of maximum benefit to the health and welfare of your dairy herd. It must also be properly installed, managed, and maintained to perform properly and to increase the life of the building in which it is installed. When these criteria are met, persons working in the pleasant surroundings of a well-ventilated barn (figures 1 and 2) will in all likelihood be more effective in their jobs. The poorly ventilated barn that is strong smelling and has a damp atmosphere is conducive to high animal disease rates and high labor turnover.

The functions of the ventilation system are: (1) to remove the moisture given off in the breath of the animals housed (about 3 gallons per 1,000 pounds of animal weight per day at 50° F); (2) to dilute the disease organisms that are shed by the cows and always present in the air; (3) to maintain a reasonably uniform temperature in winter (40°-45° F); and (4) to prevent the barn temperature in summer from rising more than about 5 degrees above the outside temperature.

In order to maintain an acceptable inside temperature in winter and to prevent condensation from occurring on even well-insulated walls and ceilings, the barn must be filled to capacity, figure 3. In mechanically ventilated calf barns supplemental heat usually must be provided.

When the outside temperature reaches about -10° F, some condensation or frost can be expected on the surfaces where the cold outside air and the warm stable air

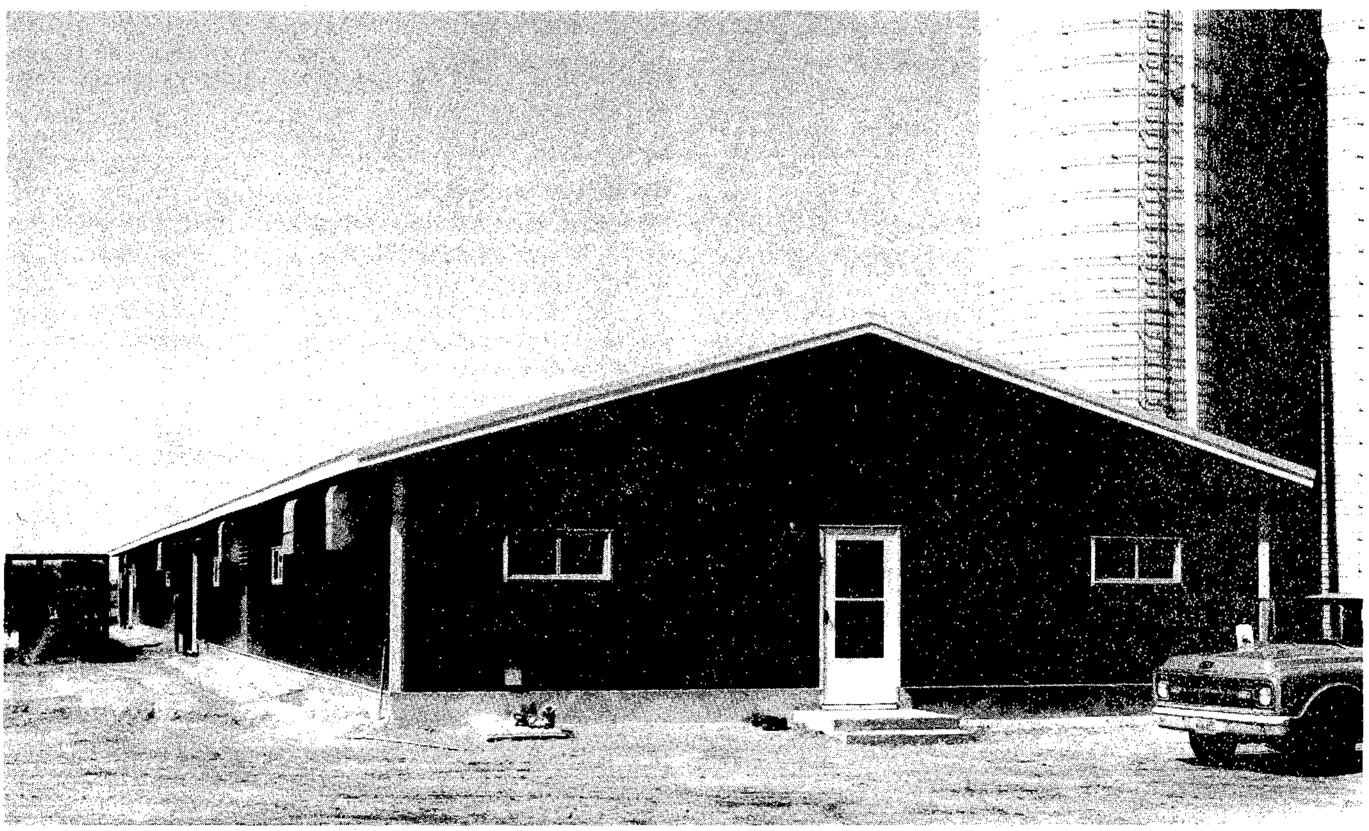


Figure 1. This new single-story, tie-stall dairy barn, 36' x 166', located in Roseau County, Minnesota, has a ventilation system planned from the principles discussed in this publication.

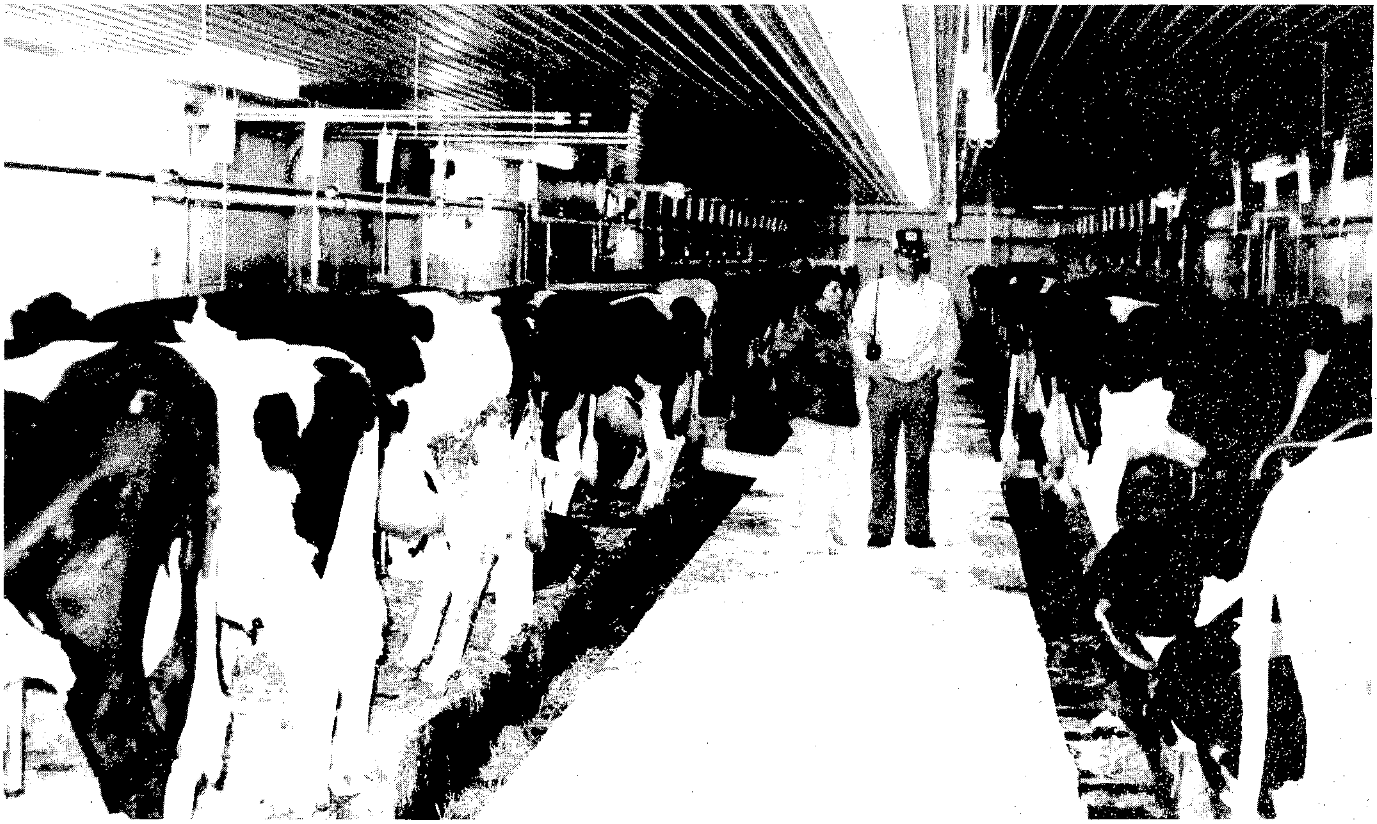


Figure 2. Interior of barn shown in figure 1. A group of three exhaust fans can be seen at the left center. A slot-type inlet is used the full length of both long walls, except directly over the exhaust fans.

meet. These conditions must be tolerated, since a system that would eliminate them would be impractical.

Insulation Necessary

A livestock building that is to be successfully ventilated must be properly insulated. R-values of about 15 for the walls and 25 over flat ceilings are recommended. (The total R-value of a wall or ceiling is a measure of resistance to the passage of heat. The higher the R-value, the better the insulation.) Because windows have a low insulation value compared to walls in which they are installed, their area should be limited. Likewise, the height of the exposed foundation should be kept as low as possible to prevent heat loss. The R-values of various building materials are given in table 1.

A ventilation system consists of two parts: the fresh air inlet system and the exhaust system; each is equally important. Emphasis is often erroneously placed only on installing fans, with little or no thought given to the fresh-air-intake system. Yet, fresh air is just as necessary for satisfactory ventilation as the fan system.

A fundamental requirement of any ventilation system is that part of it *operate continuously.* The system must be flexible in capacity to provide a minimum *continuous* exhaust of about four air changes per hour for controlling moisture, odors, and airborne disease organisms in cold weather. About 10 times this rate (40 air changes per hour) is needed for the removal of excess animal heat in warmer weather. The total capacity is then made up of the continuous fan or fans and a number of thermostatically controlled fans that turn on and off to regulate barn temperature, figure 4. Approximately one-half of the total capacity should be considered the winter, spring, and fall part of the system. The remaining one-half is for summer or mild weather use only, figure 5.

Determine Fan Capacity

The determination of a ventilation system's winter capacity for moisture removal and temperature control has been calculated on the basis of weight of the animals housed. However, the exact weight of the animals to be housed seldom is known, and, in addition, that weight does not remain constant. A simpler method of determining exhaust capacity is on the basis of a minimal number of air changes needed per hour to remove moisture and to maintain reasonable air purity, and a practical maximum to control temperature. On the basis of cooperative research between the University of Minnesota's Department of Agricultural Engineering and College of Veterinary Medicine, together with field experience, we have arbitrarily established the minimum air exchange rate to be four air changes per hour. Remove this air at a point about 15 inches above the floor, through a duct built around the continuous fan or fans when more than one is used, figure 4. In summer, an exhaust capacity of 40 air changes per hour is necessary to prevent the temperature in the building from rising more than about five degrees above the outside temperature. A higher rate of air removal will make little difference in barn temperature and is

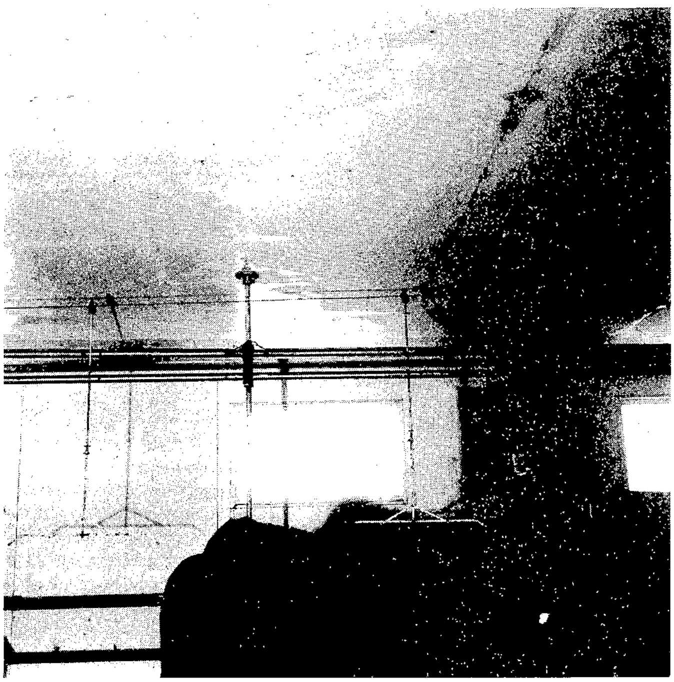


Figure 3. The ceiling in this well-insulated barn is dry over the cow, which is the last one in a row of 28, but wet over the unoccupied stall at the left because there is insufficient heat in this area. Underpopulated buildings require supplemental heat if they are to remain dry in severe winter weather.

uneconomical. It will not provide noticeably increased air velocity around the animals or persons who may be in the structure. Air within the animal housing area can be effectively mixed by providing strategically placed circulating fans manually controlled by on-off switches when the inside temperature is above 70° F.

When winter temperatures decrease to approximately -10° F, the continuous air exchange rate may have to be *reduced* slightly for short periods of time to prevent the inside barn temperature from decreasing below 40° F. This can be done by turning off one fan when there is more than one in continuous operation. It can also be accomplished by throttling the airflow through the duct to a single continuous fan.

Fan capacity required for a particular barn in cubic feet per minute (cfm) can be easily determined. Multiply the length of the structure times the width times the height to obtain the volume.* $\frac{WxLxH}{15} = cfm$ To calculate the practical maximal capacity of 40 air changes per hour in cfm for summer, multiply the minimal rate already determined by 10.

*In barns with connected manure storage, include that volume when calculating ventilation capacity.

Rate Calculation Example

As an example of ventilation rate calculation, consider a stall barn for 60 cows. A modern barn accommodating this number of cows would likely be 36 feet wide and 160 feet long, including two pens. A common ceiling height is 8 feet. Thus, the volume would be 36' x 160' x 8' = 46,000 cubic feet. (Note: ≃ shows that results are rounded to avoid uneven numbers.) To calculate the needed fan capacity of four air changes per hour in cubic feet per minute (cfm), divide the volume by 15; 46,000/15 ≃ 3,000 cfm. The maximal practical summer capacity is 10 times this; 3,000 x 10 = 30,000. This total capacity must be supplied by a number of fans, all of which should be single speed and *rated* to perform against specified static pressures. About one-half of this total, 15,000, should be considered the fall, winter, and spring part of the system. Thus, 15,000 - 3,000 (minimum continuous) = 12,000 cfm remaining. Divide this capacity among three fans of 4,000

Table 1. Insulation values.
From 1981 ASHRAE Handboook of Fundamentals. Values do not include surface conditions unless noted othrewise. All values are approximate.

Material	R-value Per inch (approximate)	R-value For thickness listed
Batt and blanket insulation		
Glass or mineral wool, fiberglass	3.00-3.80*	
Fill-type insulation		
Cellulose	3.13-3.70	
Glass or mineral wool	2.50-3.00	
Vermiculite	2.20	
Shavings or sawdust	2.22	
Hay or straw, 20"		30+
Rigid insulaiton		
Exp. polystyrene,		
extruded, plain	5.00	
molded beads, 1 pcf	5.00	
molded beads, over 1 pcf	4.20	
Expanded rubber	4.55	
Expanded polyurethane, aged	6.25	
Glass Fiber	4.00	
Wood or cane fiberboard	2.50	
Polyisocyanurate	7.04	
Foamed-in-place insulation		
Polyurethane	6.00	
Urea formaldehyde	4.00	
Building materials		
Concrete, solid	0.08	
Concrete block, 3 hole, 8"		1.11
lightweight aggregate, 8"		2.00
lightweight, cores insulated		5.03
Metal siding	0.00	
hollow-backed		0.61
insulated-backed, ⅜"		1.82
Lumber, fir and pine	1.25	
Plywood, ⅜"	1.25	0.47
Plywood, ½"	1.25	0.62
Particleboard, medium density	1.06	
Hardboard, tempered, ¼"	1.00	0.25
Insulating sheathing, 25/32"		2.06
Gypsum or plasterboard, ½"		0.45
Wood siding, lapped, ½"x8"		0.81
Windows (includes surface conditions)		
Single glazed		0.91
with storm windows		2.00
Insulating glass, ¼" air space		
double pane		1.69
triple pane		2.56
Doors (exterior, includes surface conditions)		
Wood, solid core, 1¾"		3.03
Metal, urethane core, 1¾"		2.50
Metal, polystyrene core, 1¾"		2.13
Floor perimeter (per ft. of exterior wall length)		
Concrete, no perimeter insulation		1.23
with 2"x24" perimeter insulation		2.22
Air space (¾" to 4")		0.90
Surface conditions		
Inside surface		0.68
Outside surface		0.17

*The R-value of fiberglass varies with batt thickness. Check package label.

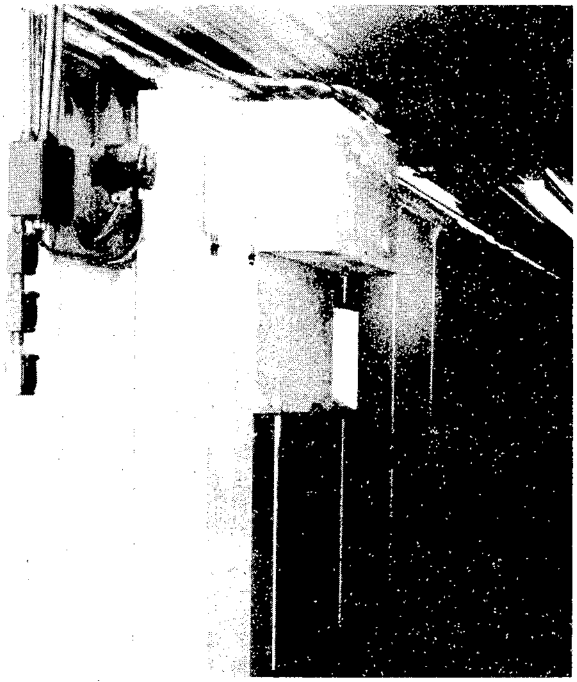


Figure 4. A close view of one group of fans in the barn shown in figures 1 and 2. The duct is built around a minimum capacity fan, which operated continuously during the winter of 1981-82 when outside temperatures fell to -40° F or lower. The spring and fall fan at the left is thermostatically controlled. What appears to be a box at the right is an insulated, removable cover for a fan that operates only in summer to prevent air leakage through and ice formation on the shutters in winter.

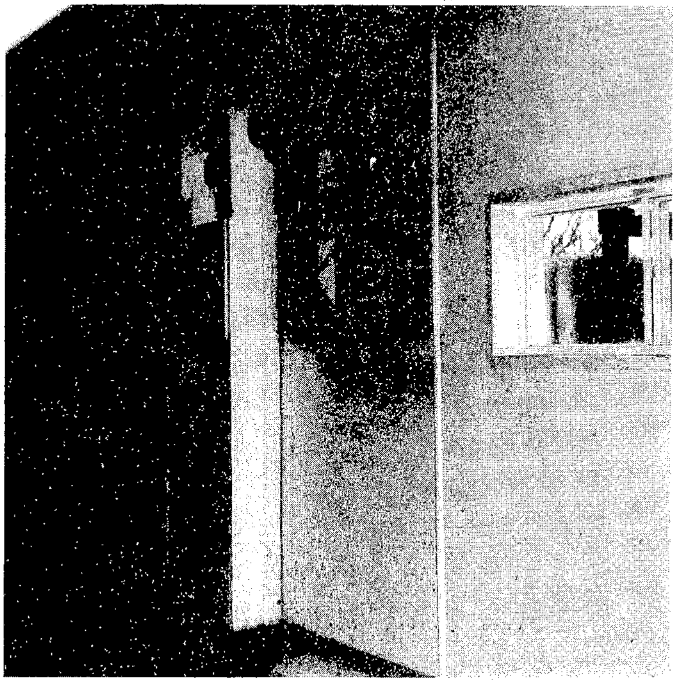


Figure 5. The summer fan shown in figure 4 in operating condition, with insulated cover removed. Door at the top of the duct built around the continuous fan is open.

cfm each to be controlled by individual thermostats. Remember that the minimum 3,000 cfm fan must operate *continuously* and be ducted to within 15 inches of the floor. Select three additional fans of 5,000 cfm for warm weather to provide the total combined fan capacity of 30,000 cfm. Fans of the exact capacities calculated will seldom be available. Except for the minimum continuous fans, choose greater rather than lower fan capacities. Control all fans except the minimum continuous portion of the system with individual thermostats set at 40°, 42°, and 45° F so that each fan will start individually. This lessens the shock effect of sudden cold air entry that would result if all the fans in the winter part of the system were controlled by a single thermostat. Set the thermostats for the summer fans at 50°, 52°, and 55° F. Suggested fan locations are shown in figure 6.

Mount the summer fans on the outside of the barn and close the opening through the wall to them with an insulated panel, figures 7 and 8, or if they are mounted in the wall, cover them in winter with removable insulated boxes fastened to the inside wall, figure 4. Either of these methods prevents the usual buildup of frost and ice on the shutters of fans that do not operate in winter. This also eliminates a possible source of cold air leaks. Some time is required to put the covers in place in the fall and remove them in the spring, but it is a simple and effective way to eliminate a predictable problem.

Fans that exhaust air from connected manure storage pits must have performance characteristics equal to or better than those installed in the walls. If they do not have these characteristics, the wall fans may overcome the manure storage area fans and draw air through the manure storage area into the barn. Increased odor and a possible health hazard to humans and animals can result. This very important point is often overlooked.

Use Fans of Known Performance

To ensure suitable performance, fans to be used must have been tested under the standard test code adopted by the Air Moving and Conditioning Association, Inc., or by another standard engineering test procedure. All fans selected should be capable of delivering their required airflow (in cfm) at ⅛-inch static pressure, figure 9. This is approximately equivalent to the pressure created by a 15-mile-per-hour wind blowing against an operating fan. Wind substantialy affects the output of ventilating fans, as does the resistance to airflow to the fans created by an insufficient air intake.

The free-air delivery performance of a fan, which is against no resistance, gives little indication of how it will perform when installed in a barn or other livestock shelter. Then the fan must operate against the resistance of the intake system and the pressure of the wind blowing against it. Likewise, the diameter of a fan is an unreliable measure of its capacity, table 2. Other factors that influence the fan's air delivery include size, shape, pitch and number of blades; turning speed; horsepower of the driving motor; and type of mounting.

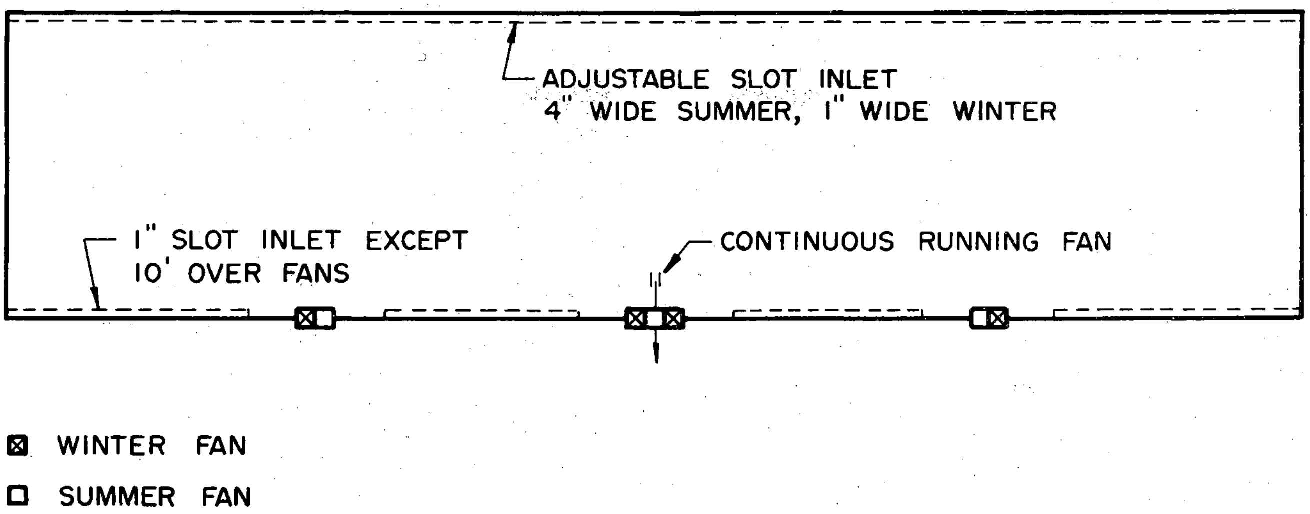


Figure 6. Schematic drawing showing suggested locations for exhaust fans in a moderate-size dairy barn. Set thermostats controlling winter fans, which includes fall and spring, from 40°-45° F. Set summer fans at 50°-55° F. Note that a fixed opening for the slot inlet system is shown along the south wall and an adjustable opening along the north wall.

As a general rule, only properly selected single-speed fans should be used in a ventilation system because of their superior performance characteristics. For a small building, usually a calf barn, it may not be possible to purchase a good-quality, single-speed fan of the capacity required. In that case, a two-speed fan having the needed low capacity against ⅛-inch static pressure may be used. Variable-speed fans are not recommended because of their general inability to develop the recommended static pressure of ⅛ inch at low speed. Thus, if a wind of about 15 miles per hour is blowing against a variable-speed fan operating at low capacity, the wind may overcome the fan and actually blow air back through it into the building, allowing an operating fan to become an air intake.

Fans used for enclosed, insulated animal shelter ventilation should be designed specifically for that purpose. They should have totally enclosed motors of the split-phase or capacitor type. Each motor should be protected by a time delay fuse or thermal overload device to eliminate risk of motor damage in case of abnormal operating conditions. Thermal overload protection is recommended for all electric motors, regardless of their use.

Rules for Locating Fans

1) In barns having solid floors and where the animals are housed throughout the year, space the fans uniformly in the south or west wall. Admit most of the incoming air along the opposite wall, figure 6. This requires the incoming air to flow across the stable in summer, when most of the incoming air is admitted on the opposite side.

It is also important that the fresh incoming air be directed downward at high velocity, in order that it reach the vicinity of the animals. On a hot summer day the outside temperature is about the same as the inside barn temperature. The weight of indoor and outdoor air is also about the same. Thus, incoming air directed across the ceiling may travel to fans placed at a high level, with very little fresh air reaching the animals. In winter, the cold outside air is heavier than the warm inside air. Fresh air entering the barn at low velocity will thus fall to the floor under the forces of gravity, creating a natural mixing within the barn without high velocity at the air intake.

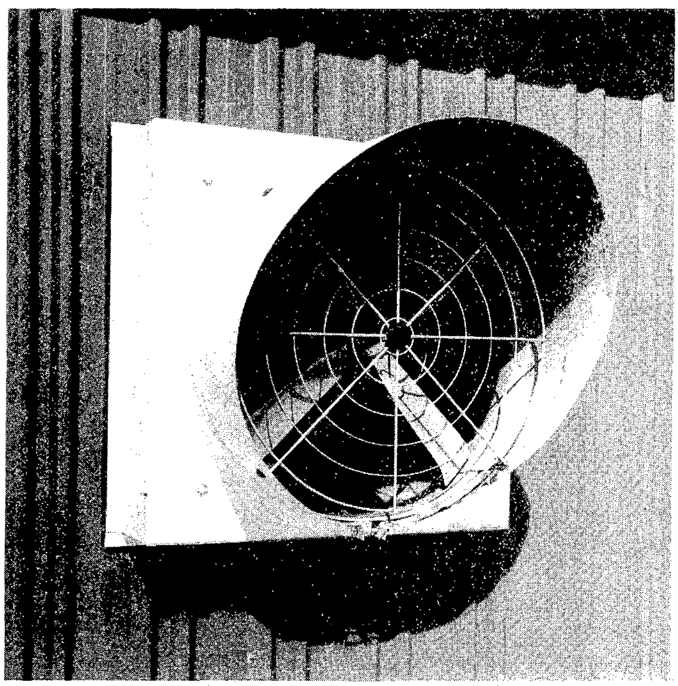


Figure 7. This summer fan is mounted on the outside of the barn wall so that air leakage and frost buildup on shutters can be eliminated in winter by an insulated wall panel, figure 8.

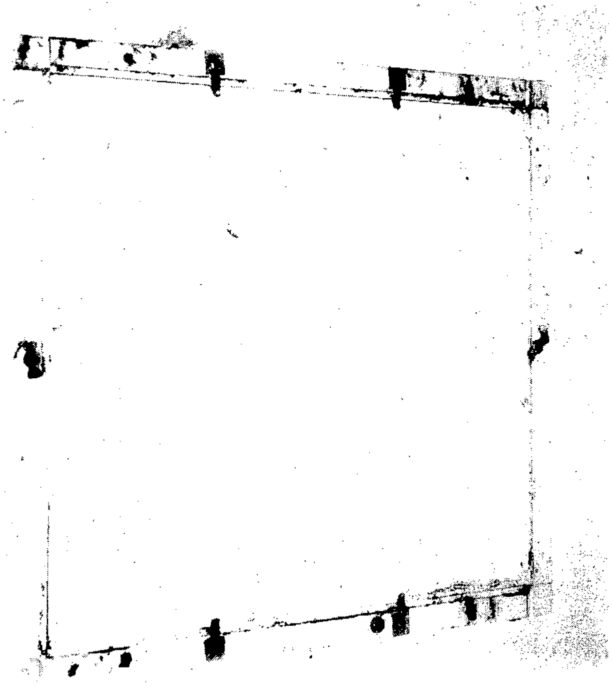


Figure 8. Removable insulated panel closing wall opening for summer fan, figure 7.

2) In slat-floor, free-stall barns or stall barns with open gutters and manure storage beneath, exhaust one-half of the total fan capacity from the storage area. Part of this capacity must be removed *continuously.* The remainder must be in operation before any of the wall fans are turned on.

3) Locate fans at least 10 feet away from doors and other openings to reduce any entering outside air from moving directly to fans before mixing with air in the building.

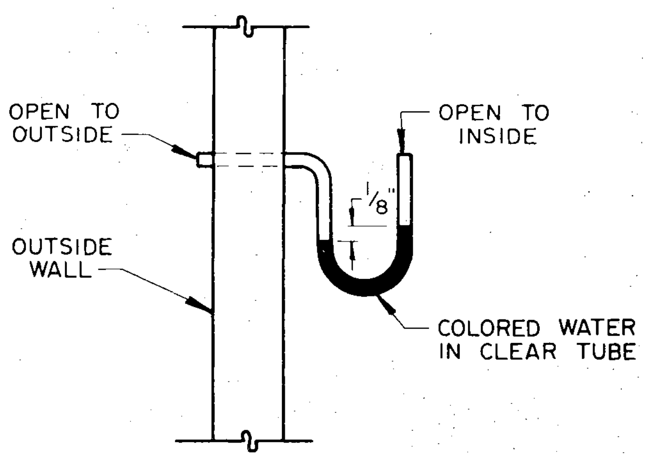


Figure 9. Static pressure is the difference in air pressure between the inside and the outside of the building measured in inches of water. It is a measure of the resistance that fans must overcome to move air through the building. This water column shows schematically a pressure difference of ⅛" (.125) between the atmospheric pressure outside and the negative (lower) pressure inside created by the exhaust fans.

4) Locate the thermostats controlling fans at eye level and toward the center of the barn. *Do not locate thermostats on an outside wall.*

In winter, maintain a temperature of 40°-45° F in dairy barns. For calf barns, about 50°-55° F is preferred. Higher inside temperatures should be avoided because it is more difficult to control moistue on the inside shell of the building in cold weather. The cost for heat is also greater.

5) Do not locate fans in calf pens in an attempt to draw heat to them. Aerosol contaminants drawn from the cows to the calves often cause disease problems and condensation in the colder area.

Wet corners frequently can be dried up by admitting fresh air. In parts of the stable where only a few animals are housed, such as in calf pens, additional insulation or heat, or both, may be required. *Ideally, calves should be housed in quarters apart from the cows.*

6) Install all wall fans near the ceiling. Build a duct around each continuously running fan to draw air from near the floor, which can be as much as 10 degrees cooler in winter than the air near the ceiling. Make the duct at least 12 inches deep and as wide as the fan frame, figure 10. Near the top, provide a door to give access to the fan. Keep the door closed in winter. It may be opened in

Table 2. Typical Rating Tables for Exhaust Fans*

			Air Delivery in cubic feet per minute (cfm) at indicated static pressure					
DIAM.	RPM	HP	0"	1/10"	1/8"	1/4"	3/8"	1/2"
8"	1650	1/50	400	316	289	—	—	—
10"	1550	1/50	594	457	413	—	—	—
12"	1550	1/30	730	—	—	—	—	—
12"	1600	1/12	1188	1073	1035	827	—	—
16"	1140	1/12	1675	1440	1374	—	—	—
16"	1725	1/3	2534	2392	2353	2142	1890	1635
18"	1140	1/6	2686	2460	2395	—	—	—
18"	1725	5/8	4065	3920	3880	3682	3445	3195
21"	1140	1/4	3812	3599	3540	—	—	—
21"	1725	3/4	4914	4770	4740	4510	4320	3920
24"	855	1/3	4691	4310	4180	—	—	—
24"	1140	7/8	6254	5990	5920	5470	4810	4220
30"	685	1/2	8112	7555	—	—	—	—
30"	855	1	10125	9700	9575	8640	—	—
36"	570	5/8	10596	9560	9220	—	—	—
42"	490	1	15630	14325	13995	—	—	—

*The purpose of this table is to show variation in performance of fans of different sizes. No endorsement of a particular manufacturer is implied or intended.

summer. A damper can be placed near the bottom of the duct to allow reduction of airflow in cold weather. The use of a duct around each continuously operating fan can mean the difference between satisfactory and unsatisfactory performance of the system when heat balance is critical.

7) In barns not filled to capacity, it is usually necessary to add heat if the walls and ceilings of the unoccupied areas, even though well-insulated, are to remain dry in severe winter weather.

8) In winter, mechanically moving air within the building, through plastic tubes or ducts, in an effort to blend cold outside air with warmer inside air is not recommended. This technique cannot make up for inadequate building construction, insufficient animal population, or poor ventilation system design. Further, such systems have the disadvantage of redistributing contaminated air through the housing compartment.

Fresh Air Needed

A fresh-air-intake system that will distribute incoming air uniformly is essential. It must have sufficient capacity to prevent the negative static pressure in the building from rising above ⅛ inch of water. Static pressure is an indication of resistance to airflow. It can be measured with a portable inclined column manometer. However, a readily available guide is the barn door. If the door slams shut or if the sound of the fans change when the door is open, there is an inadequate supply of fresh air entering the building.

Poor fresh-air-intake design is one of the most common causes of unsatisfactory ventilation performance. The primary function of a fresh-air-intake system is to distribute incoming air uniformly throughout the building in a manner that will not cause undue drafts in winter. This is best accomplished by bringing a small amount of air in at many places. At the immediate point of entry, however, cold will be felt regardless of the inlet system design, unless heat is added to the incoming air. When cold incoming air is warmed, its moisture-holding capacity is greatly increased. This enables the air to absorb moisture produced by the animals, thereby allowing the exhaust system to carry it outside. Further, the air replacement process allows for the dilution of disease-causing aerosol contaminants from the animals, preventing a buildup of those organisms and thereby improving air purity. Continuous exhaust is thus mandatory from this standpoint alone, a fact that is often unrecognized.

The slot inlet system, figures 11 and 12, has proved to be an efficient and economical means of bringing fresh air into any mechanically ventilated livestock housing unit. Because of its low cost and simplicity of construction, it is sometimes disregarded. (Often more expensive equipment is assumed to be of better quality.) Our experience over more than 30 years indicates that there is no system that will outperform the slot inlet.

A slot inlet can best be built into a barn during construction. It is a continuous narrow opening to the attic or hay mow at the junction of the ceiling and the walls, except for a distance of 10 feet above each wall exhaust fan. Air is drawn into the barn through this inlet by the exhaust fans.

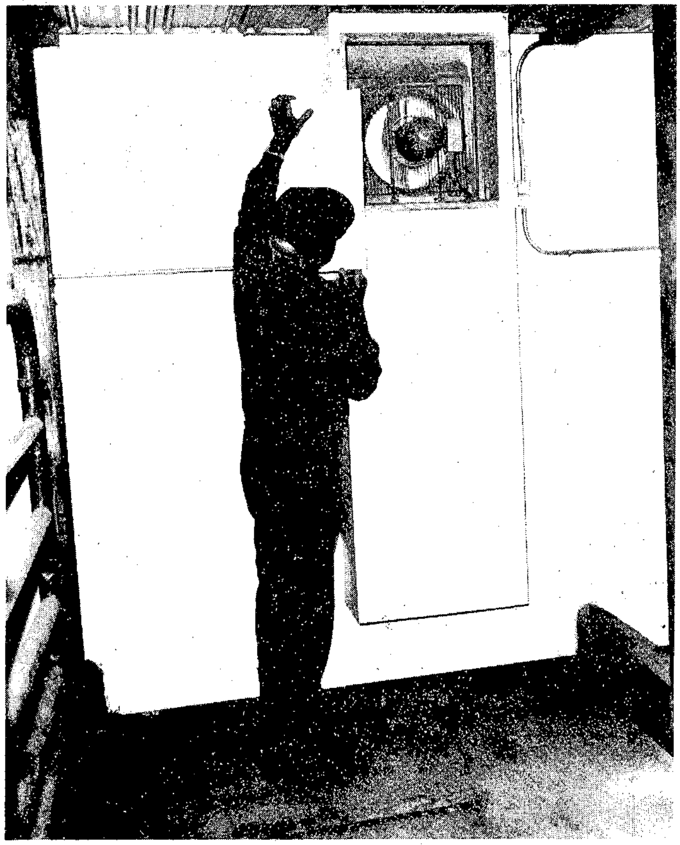


Figure 10. In winter, air near the floor in a livestock building can be as much as 10 degrees cooler than air near the ceiling. To conserve heat and energy, a duct as shown should always be used around the continuously operating exhaust fan or fans. An equal amount of moisture but less heat is removed than when air is exhausted from the ceiling, making a higher ventilation rate and thus greater dilution of contaminated barn air possible.

The amount of air that enters is determined by the amount exhausted. There must be continuous exhaust from the building to prevent back draft of stable air through the slot to the space above it.

The slot intake system for single-story barns should have two capacities — one for winter, spring, and fall, and one for summer. In winter, there should be an opening about 1 inch wide on both sides of the building, figures 13 and 14. This allows nearly uniform air entry throughout the barn. A minimal velocity of about 150 feet per minute (fpm) should be maintained to eliminate back draft through the slot. In summer, a maximal velocity of 800 fpm is recommended when the exhaust system is operating at full capacity. The adjustable slot, which is 4 inches wide, must then be fully opened. A velocity of about 800 fpm is obtained when there is an airflow of 800 cfm through an opening 1 inch wide and 12 feet long.

For example, consider the barn 36 feet by 160 feet, previously mentioned. Assume that the building is to have a minimum of 4 and a maximum of 40 air changes per hour. The minimal fan capacity is 3,000 cfm and the maximal capacity is 30,000 cfm. Assume that this capacity is divided among seven fans to be placed in the south

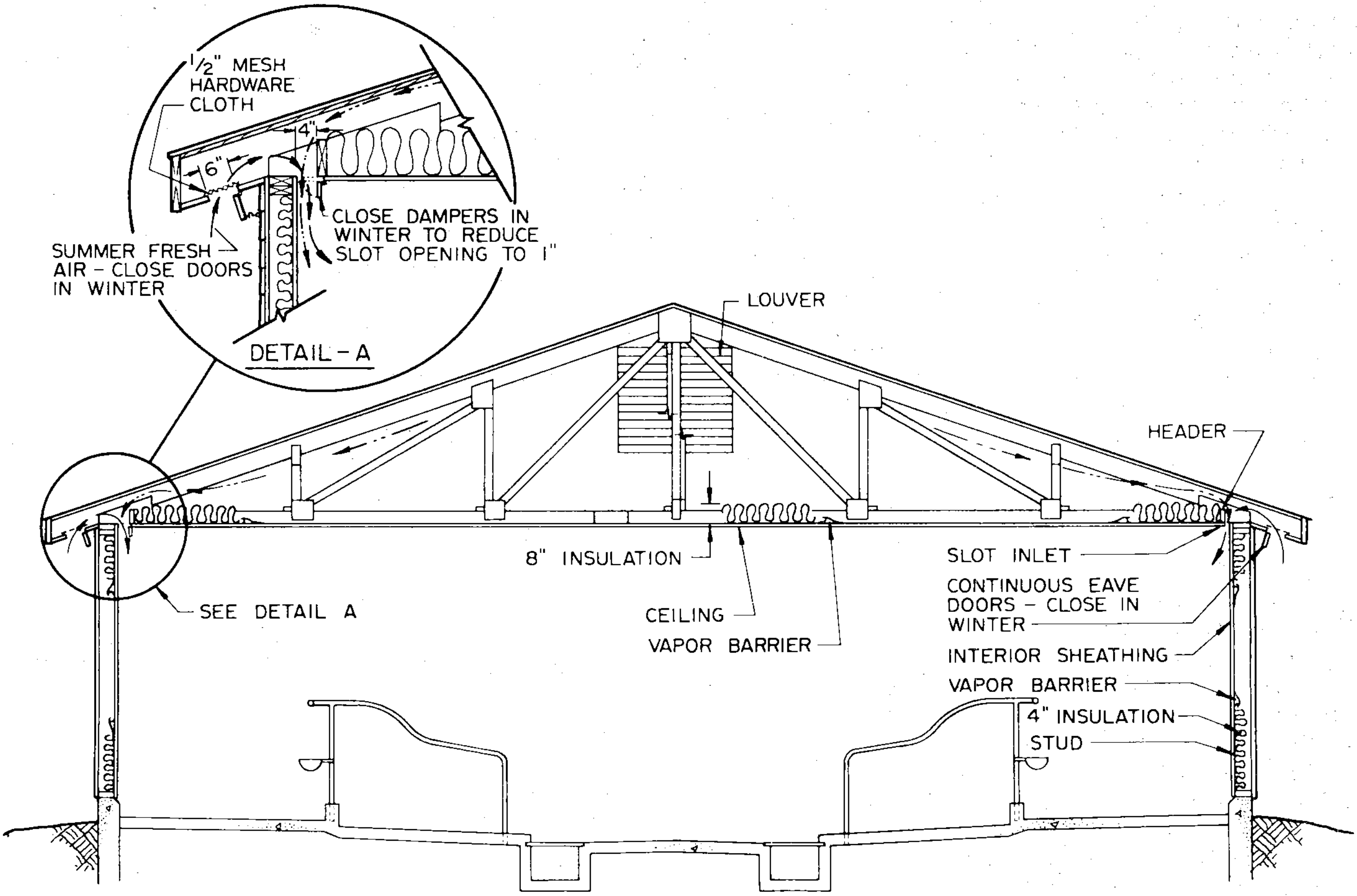


Figure 11. This cross section shows the construction of a slot fresh-air-inlet system for a single-story barn. A slot width of 1 inch is shown for the south or west side, depending on the direction of the barn. On the north or east, the slot width is 4 inches for summer ventilaton. This permits entry of most of the summer air from the shaded side of the barn through adjustable openings under the eaves, figure 15. Fans should be on the opposite side, figure 6. In winter, eave openings are closed and slot width is reduced to 1 inch with an adjustable damper or slide, figure 14. Louvers at least 4 square feet must be provided in each gable to permit entry of winter air. Four inches of wall insulation and 8 or more inches of ceiling insulation is recommended.

wall. The slot should be closed for a distance of 10 feet over each fan. Thus, 70 feet of the south wall would be without a slot, leaving 90 feet of slot. The north side would be unobstructed the full length, or 160 feet. For winter operation, then there would be 250 feet of slot, 1 inch wide.

$$\frac{\text{250 feet x 12 inches}}{\text{144 inches}} \simeq \text{21 square feet of slot area}$$

$$\frac{\text{3,000 cfm}}{\text{21 sq. ft}} \simeq \text{143 feet per minute velocity under minimal conditions, which is adequate.}$$

During the summer, it is essential to prevent the inside barn temperature from rising appreciably above the outside temperature. Thus, it is an obvious advantage to draw the coolest air available into the barn. The north side of the barn is least affected by the sun; next coolest is the east side. For a barn having an east-west orientation for the long dimension, most air should be drawn from the north side. For a barn having a north-south orientation for the long dimension, most air should be drawn in from the east side. Six-inch-wide continuous doors or slide-regulated openings should be built into the underside of boxed-in eaves. These are opened in summer to permit outside air from the shaded area beneath the eaves to enter the slot, figures 11 and 15. Because the incoming air can quickly enter the ceiling slots, there is little opportunity for it to be warmed in the attic. The eave openings may also allow greater natural air movement through the attic as a result of wind action and convection, thereby reducing temperature buildup in that space.

In winter, the eave openings must be closed. Then, all air entering the barn through the slot inlet is supplied by attic louvers.

By constructing a wider slot opening into the barn along the north or east wall, as the case may be, best advantage can be taken of natural conditions. This slot opening should be 4 inches wide and have a hinged damper or slide, figure 14. It can then be closed to 1 inch in winter. Most of the summer air will come in through the full opening because there is less resistance across the greater width. By placing all exhaust fans on the opposite side of the barn, cross-ventilation results, figure 8.

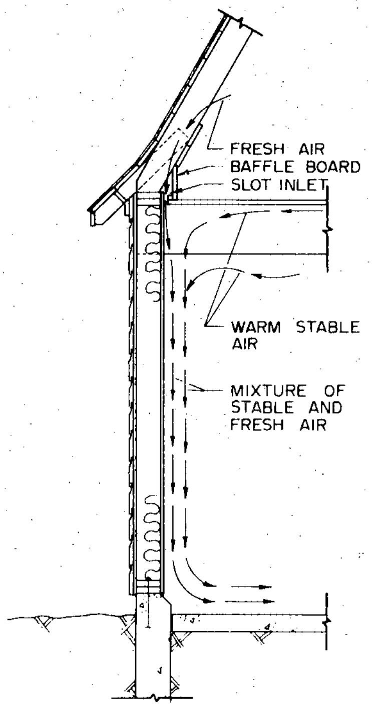


Figure 12. Typical design for a slot inlet for winter air entry in a two-story barn. Air must be admitted through windows or other wall openings on summer days when it is very hot in the hay mow. Blanket insulation should be provided in the walls. Ceiling insulation can be provided by hay or straw stored overhead, providing a minimum depth of about 2 feet is maintained, otherwise wet spots will develop on the ceiling (underside of mow floor).

Figure 13. This slot inlet 1 inch wide extends the full length of the south wall on an 80-cow, single-story barn (except for 10 feet over each wall exhaust fan). It remains the same in both winter and summer.

In winter, with the damper closed, approximately the same amount of air will enter on both sides. Because the incoming air is cold, and therefore heavier, convective forces cause natural air mixing. Some moisture or frost will form at the edges of the slot during prolonged severe weather, figure 4, but this will take place in any system at the point where cold outside air and warm stable air meet, figures 16 and 17. Condensation and frost formation can be eliminated only if the incoming air is warmed to a temperature above the dew point of the air in the stable, figure 18. It cannot be eliminated by the so-called tempering process. This is where stable air is blended with outside air in an attempt to raise the temperature of the latter. An interface must occur between the warm and the cold air, with resulting condensation.

For buildings wider than about 42 feet, fresh air also must be admitted near the center of the barn through an additional slot or row of ceiling intakes. Such barns are usually more difficult to ventilate satisfactorily.

During winter, outside air to supply the slot inlet should be admitted to the attic through large louvers built high in the gable at each end of the barn, figure 11. As a general rule, build each louver about twice the combined size of the openings for the fans in the stable below it. Louvers should be screened with ½-inch mesh hardware cloth to prevent the entrance of birds. Window screen should not be used because it will quickly be plugged with airborne debris, thereby greatly reducing airflow. For barns in unprotected locations, it may be necessary to install spe-

Figure 14. An adjustable slot inlet in the winter position. Picture was taken on a day when the outside temperature was -34° F. Some condensation is evident, which is normal. In summer, the baffle is moved inward to the ceiling stops, enlarging the opening at the wall to 4 inches.

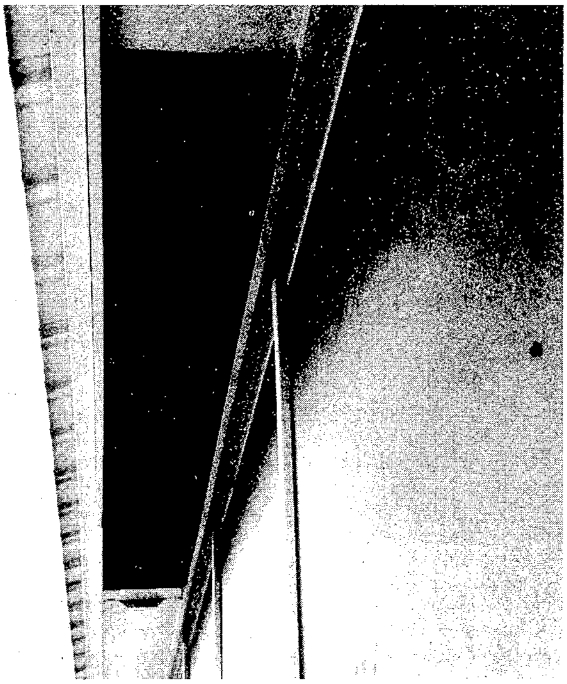


Figure 15. Under eave opening along the north side of the dairy barn for 80 cows shown in figure 14, in summer position. Note the coarse screen to prevent plugging with debris. In addition to providing fresh air for the slot inlet system, eave openings permit increased air movement through the attic.

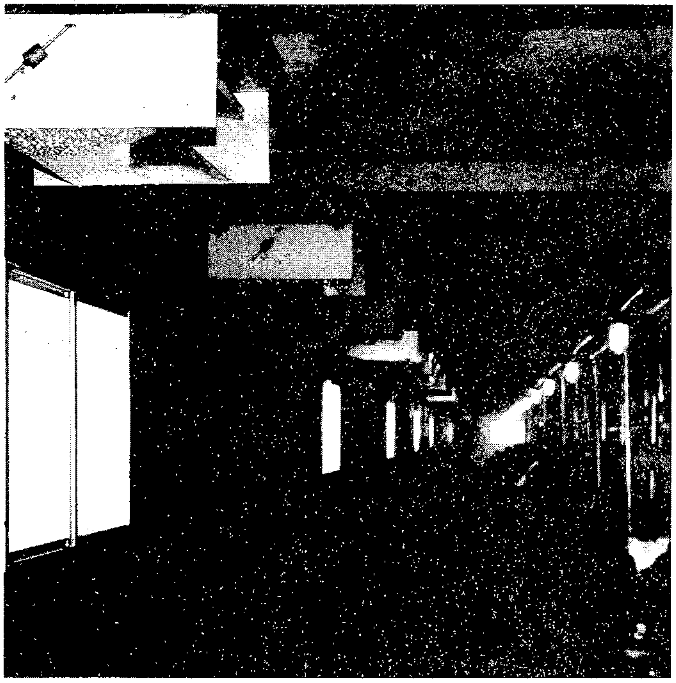


Figure 16. Commercially built individual ceiling intakes in a new two-story dairy barn. Note condensation on the underside, which developed when the outside temperature was about 15° F.

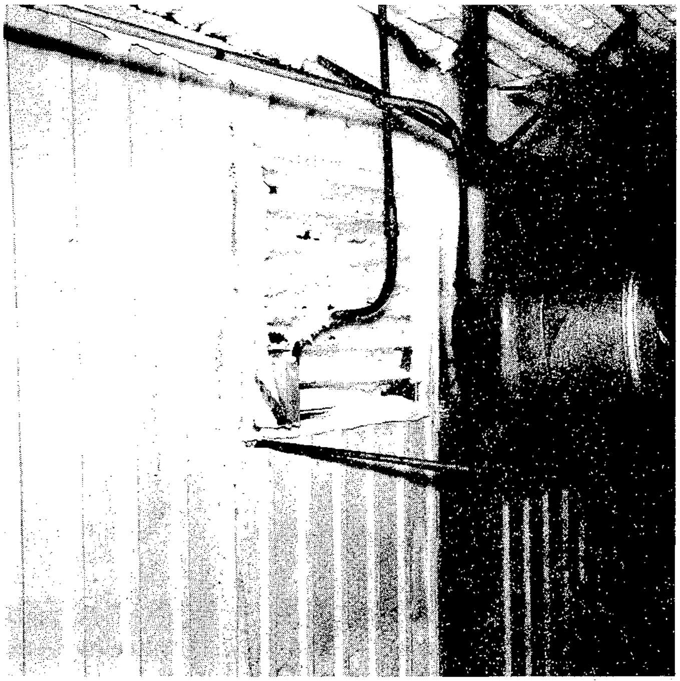
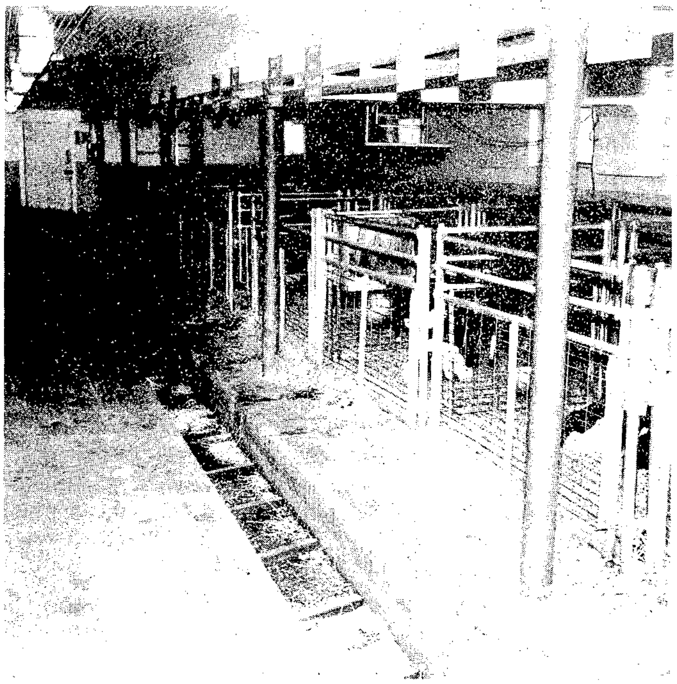


Figure 17. Frost formation on metal parts of a commercial fresh air intake serving a slat-floor young stock barn at the Unversity of Minnesota Northwest Experiment Station, Crookston. Picture was taken on the same day as that in figure 18.



Figue 18. Fresh-air-intake duct in a calf barn was taken on the same day and at the same geographic location as in figure 17. Outside temperature was -20° F. No frost or condensation is present because all the incoming air passes over a furnace and is warmed well above the dew point of the air in the barn. Calf barn has a continuously operating exhaust fan with a duct built around it. Temperature control is on the furnace located outside the barn in a separate small building. Supplemental heat, the distribution duct, and continuous ventilation have reduced calf losses from environmentally related causes to nearly zero.

cially built hoods, figure 19, to prevent snow or rain from blowing through the louvers and into the attic under extreme wind conditions.

With use, even properly designed intake systems may become restricted by debris, figures 20 and 21. Intakes are sometimes deliberately plugged in a misguided attempt to reduce drafts, figure 22. A yearly inspection and proper maintenance are thus essential.

Ventilating the Older Barn

Providing satisfactory ventilation in many older dairy barns is a difficult and sometimes impossible task. These barns are usually poorly insulated, perhaps having stone or concrete block walls, single windows, and loose-fitting doors. One or more fans are often installed in an attempt to improve conditons, with only mediocre results. The degree of improvement will depend on the construction and state of repair of the building. Suitable air inlets are difficult to provide. As a result they are usually not installed. Consequently, air enters through available openings such as the gutter cleaner exit, around loose-fitting sliding doors, and hay chutes. Do not expect to make up for building deficiencies by installing a system that recirculates stable air, combined with intermittent exhaust fan operation, or one that blends inside and outside air according to weather conditions. These units usually do not perform in a satisfactory manner.

In two-story barns with mow floors and no ceiling on the underside of the joists, a satisfactory inlet system can be installed. This is accomplished by drilling 2-inch holes, figure 23, about 10 inches on center through the floor to the space above. These holes extend the full length of both long walls, except for a distance of 10 feet over each fan. Provide protection in the mow, figures 24 and 25, to prevent the holes from becoming plugged.

If there is both a mow floor and a ceiling, *do not* drill the holes, because cold air will then circulate in the space between. The ceiling will then become wet because the insulation value of hay or straw stored above it will be lost, and ceiling condensation will occur.

In single-story barns with an insulated ceiling but no air intake system, it is more practical to install commercial or home-built ceiling intakes, figures 12 and 26, than to attempt installing a slot inlet.

Fan Maintenance

Ventilation fans, like other pieces of mechanical equipment, need periodic maintenance. Usually the bearings are permanently lubricated, but regular inspection and cleaning of the fan blades, and particularly the shutter, is essential, figure 27. Accumulated dirt greatly reduces air output and, as a consequence, there will be insufficient airflow through the building. Inspect all fans at least once a year.

Manure storage fans are constantly exposed to corrosive conditions that cause more rapid deterioration of metal than is the case with wall fans. Thus, earlier replacement may be necessary.

Careful management of any ventilation system is necessary for successful performance. There is no substitute for common sense and routine maintenance in operating it.

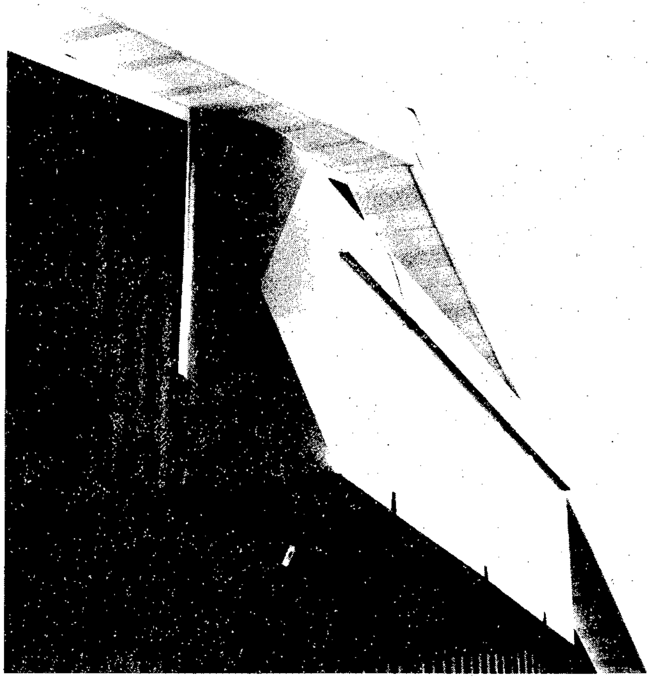


Figure 19. Experimental metal hood installed to prevent strong winter wind from blowing directly into the end louvers of the dairy barn shown in figure 1, and carrying snow in. Barn is completely unprotected. Winds of up to 80 mph were experienced the first winter of use, 1981-82.

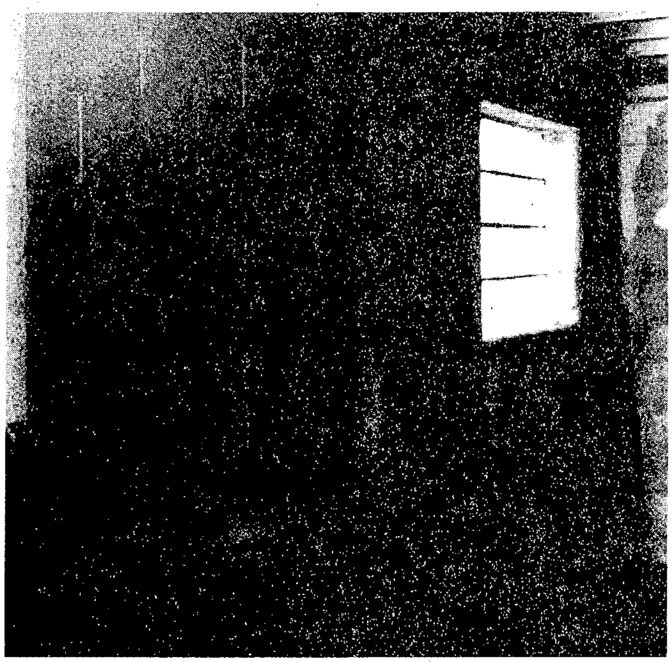


Figure 20. Masonry block walls of a two-story stall dairy barn a slot inlet built in 1964. Picture was taken on a cold day in 1979. The slot inlet had become partially plugged with hay and chaff. Periodic maintenance is essential. Light-colored areas show effect of fresh air in keeping walls dry. Note ice buildup on glass block windows.

Figure 21. Air supply to ceiling intake in stable below must enter through this plugged opening in mow of two-story barn. Little air can pass through. Result, poor ventilation system performance.

Figure 22. This ceiling intake through the ceiling of a two-story calf barn was deliberately plugged to "prevent draft." Result: faster air entry and more draft through remaining open intakes. Closing intakes will not solve a ventilation problem; it only makes matters worse. The underlying cause must be determined and corrected.

Figure 23. A satisfactory winter-air-intake system was made in this two-story barn by drilling 2-inch diameter holes about 10 inches on center through the mow floor to the space above.

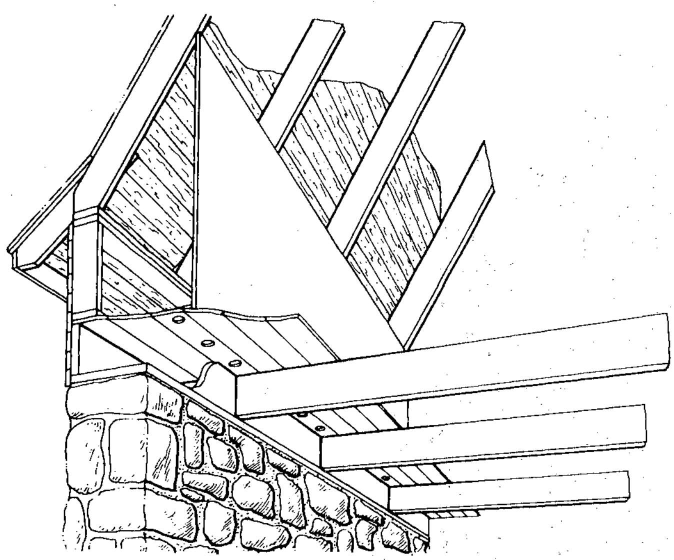


Figure 24. Drawing showing method of providing mow protection for a bored-hole-intake system in a two-story dairy barn as shown in figure 23.

Figure 25. Protection built into the mow of an old, two-story barn to allow slot inlet through floor into stable to remain open. System was put in when barn was about 40 years old. Performance has been good. Installing only fans in a barn cannot solve a ventilation problem. The fresh-air-intake system is equally important. Providing it may not be easy, but there is always a way to do it.

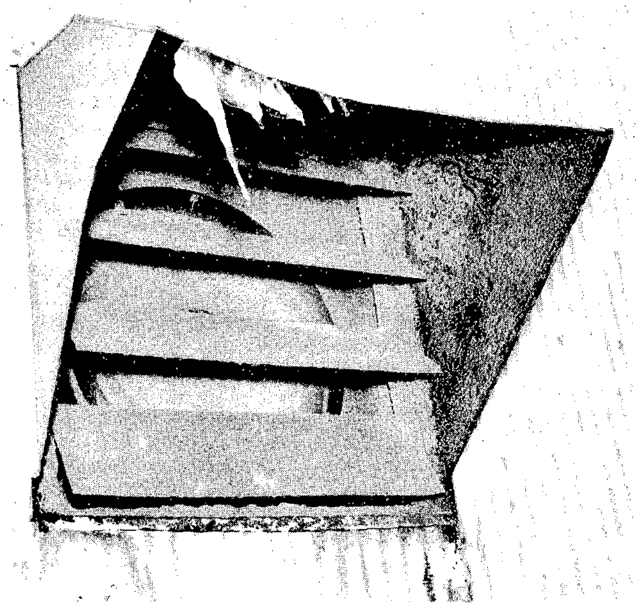


Figure 27. Proper maintenance of exhaust fans is essental. Here the shutters have become so clogged with dirt that they only partially open, greatly reducing the air delivery of the fan.

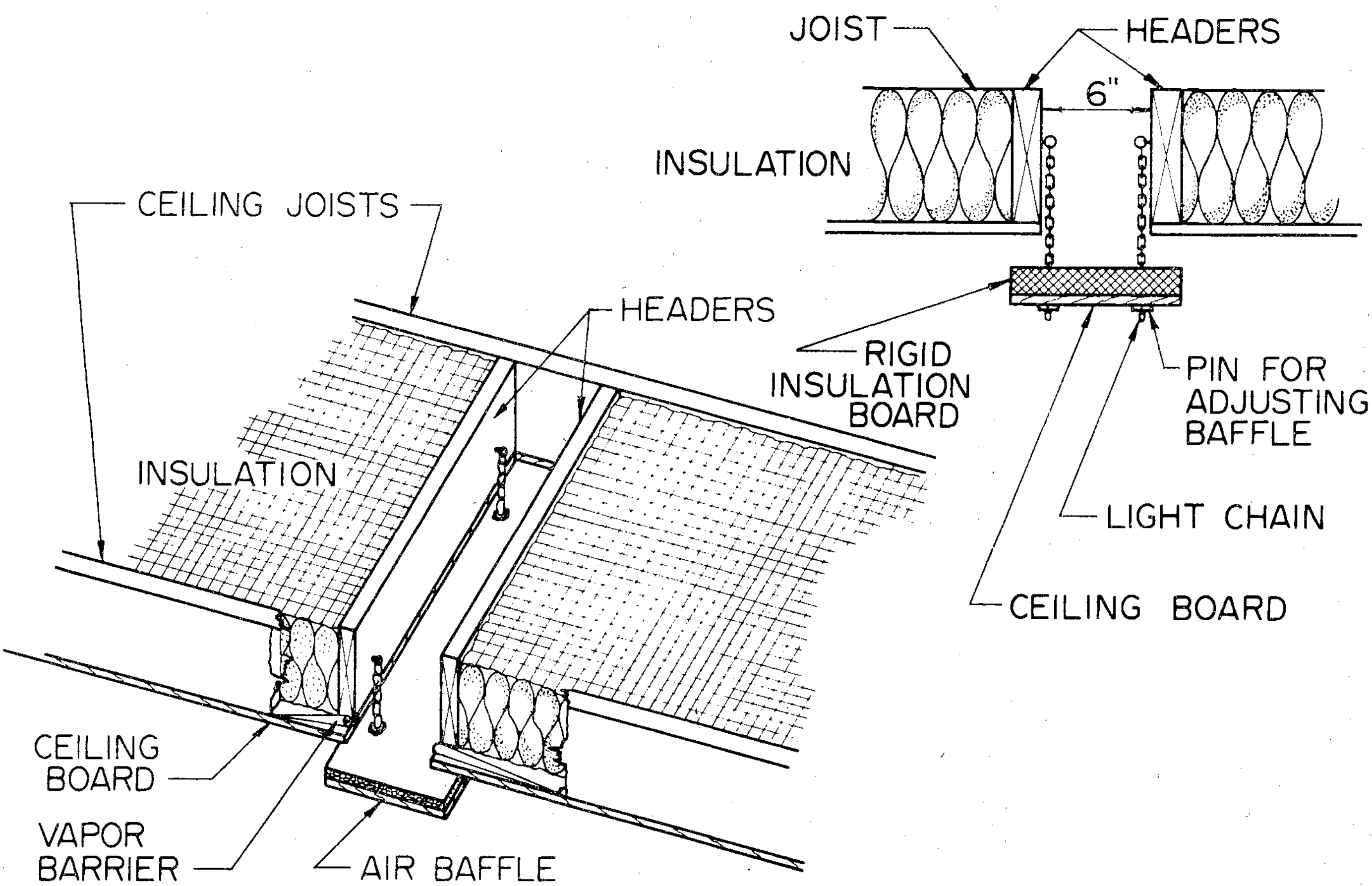


Figure 26. Construction details for a home-built ceiling intake. Headers are placed between ceiling joists with a space between them to give an opening of about 1 square foot. One ceiling intake is then equal to a slot inlet 1 inch wide and 12 feet long. Normally two rows of ceiling intakes are placed at intervals of 12 feet down the length of the barn as close to the walls as possible. Be sure to have enough inlets to permit the entering air velocity to remain below 800 feet per minute.

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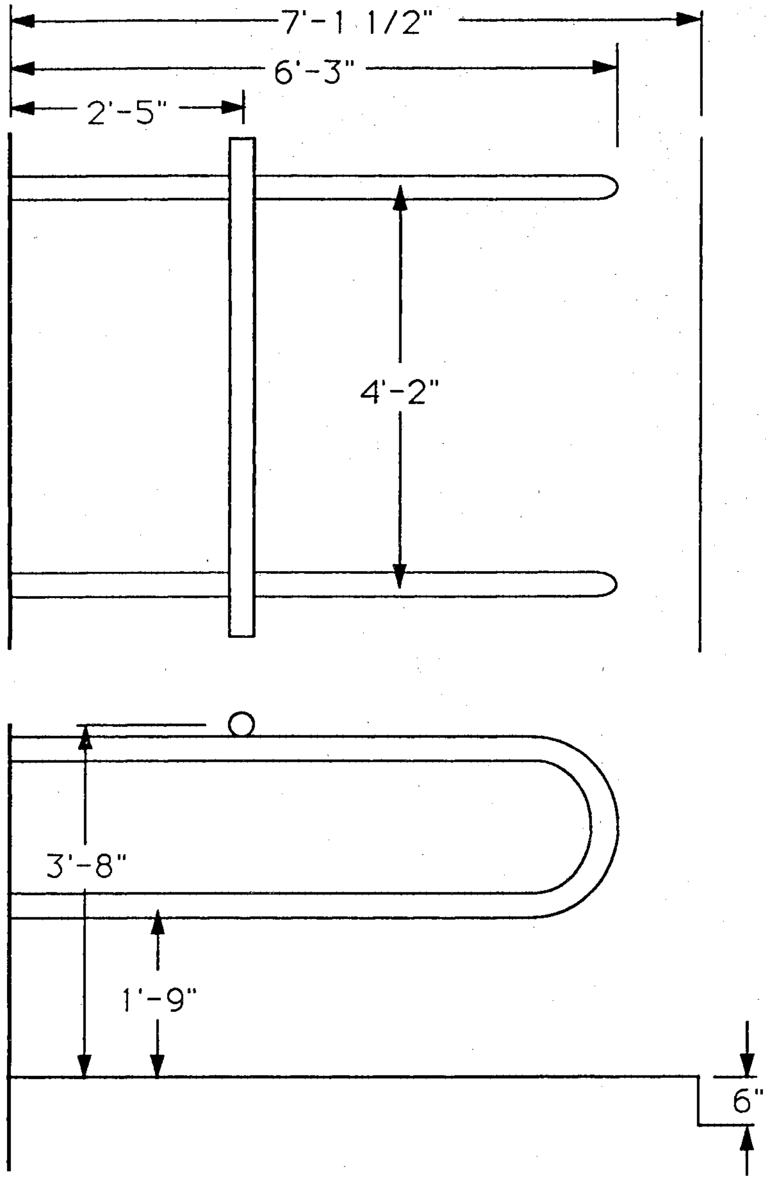
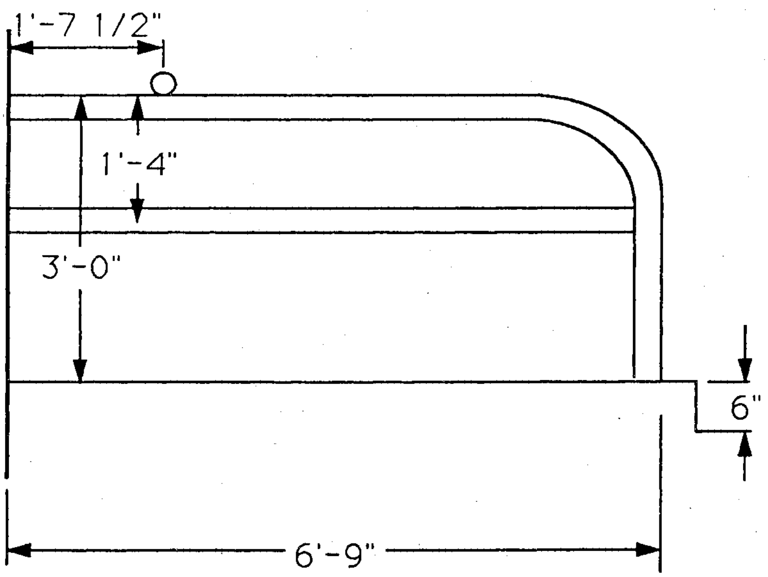


New
Divider



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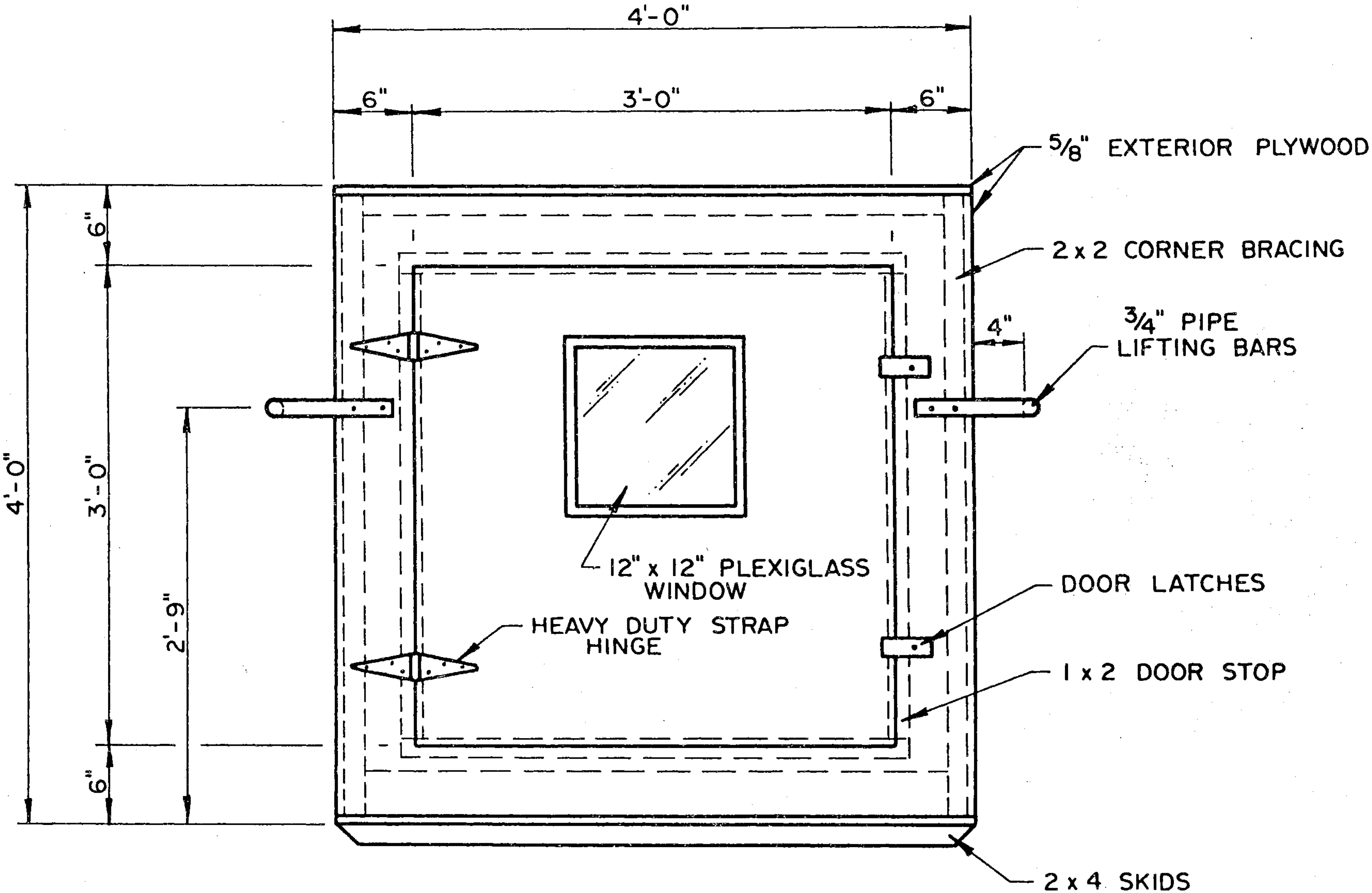
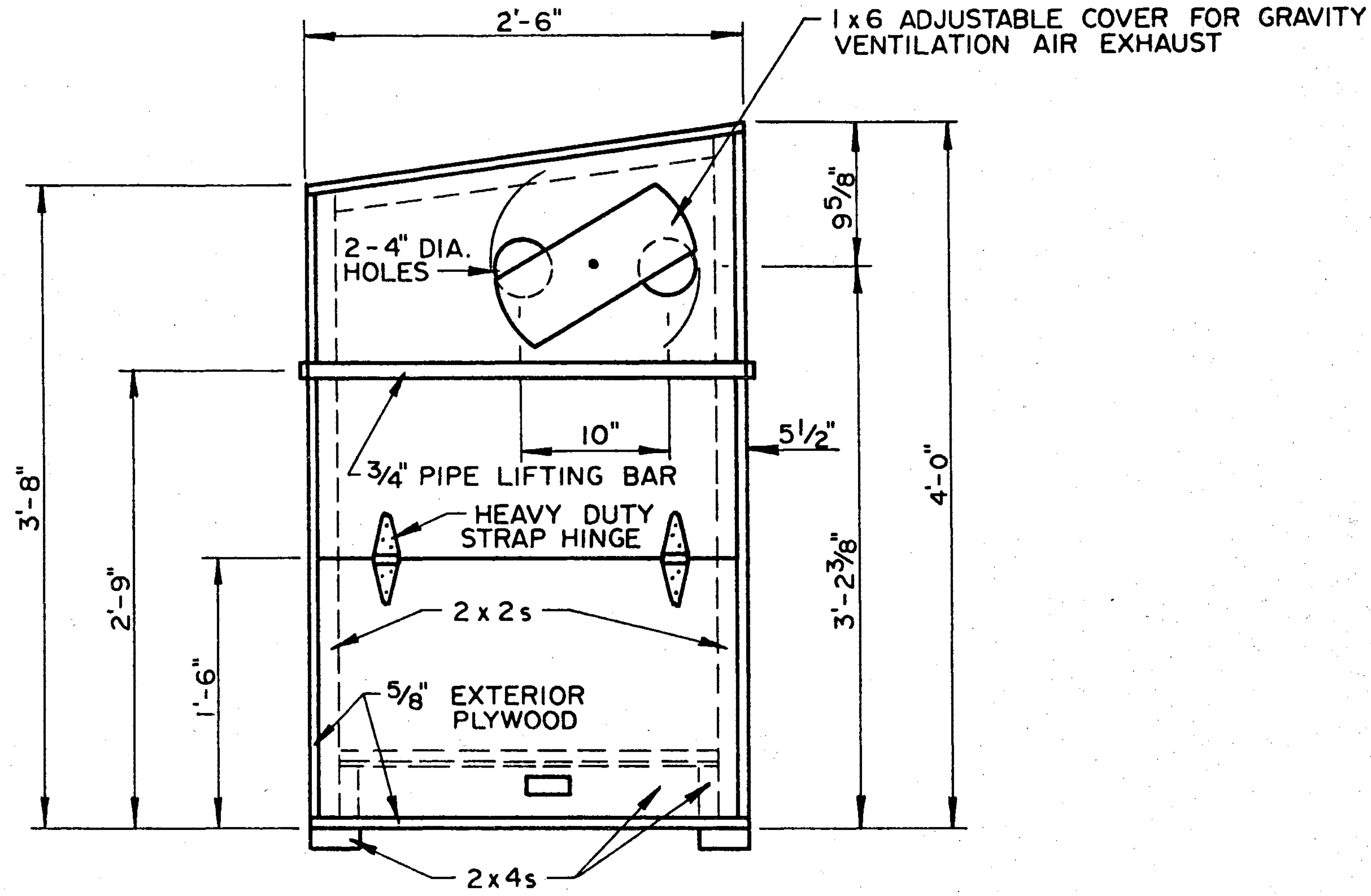


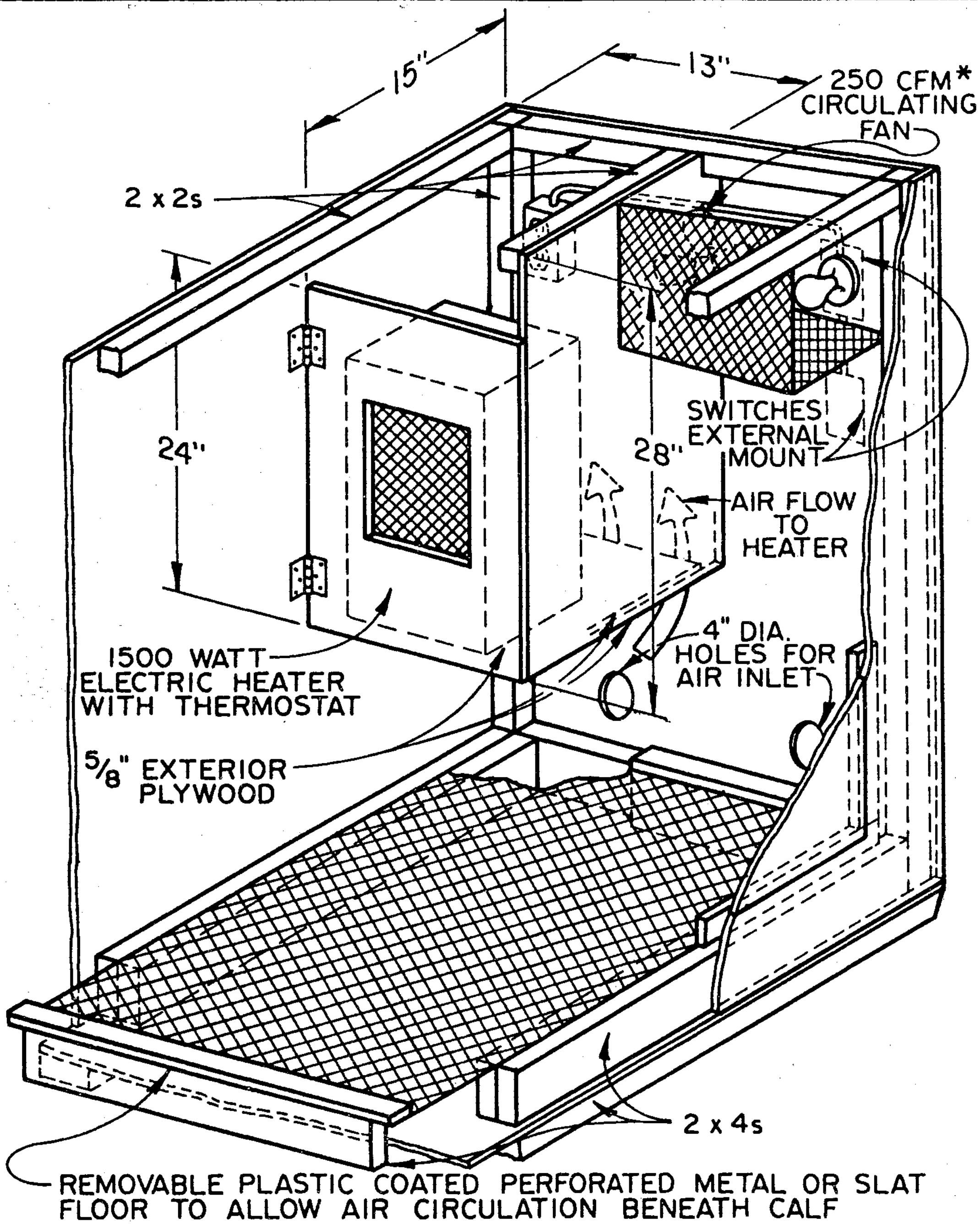
SIDE VIEW

UNIVERSITY OF MINNESOTA EXTENSION AGRICULTURAL ENGINEERING	Dsgn. by D.W.Bates J.F. Anderson	
	Drwn. by JN	1 of 3
CALF WARMING BOX	Rev. 2/87	
	Scale 1"=1'	



END VIEW

UNIVERSITY OF MINNESOTA EXTENSION AGRICULTURAL ENGINEERING	Dsgn. by D.W.Bates J.F. Anderson	
	Drwn. by JN	2 of 3
CALF WARMING BOX	Rev. 2/87	
	Scale 1" = 1'	



MANAGEMENT INSTRUCTIONS

This unit was specifically designed to provide a favorable environment for weak dairy and beef calves or for those calves born under adverse temperature conditions. Use the following procedure.

1. Feed calf 2 quarts of colostrum immediately following birth and again at 6, 12 and 18 hours.
2. Administer veterinarian prescribed medication and vaccination.
3. Apply naval clip and or dip naval in iodine.
4. Place calf in prewarmed calf warming box and maintain 90°F temperature.
5. Observe calf periodically for activity and progress of drying. Remove calf when dry.
6. Brush hair coat erect.
7. Place calf in well bedded outside individual calf hutch.
8. Continue with recommended calf management program.
9. Warming box is suitable for both indoor and outdoor use.

*CFM = cubic feet of air per minute

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	Drwn. by JN	3 of 3
CALF WARMING BOX	Rev. 2/87	
	Scale 1"=1'	

Approximate Bill of Materials

NUMBER	DESCRIPTION
4	2 x 4 x 8' – runners and floor supports
4	2 x 2 x 8' – framework
1	1 x 6 x 2' – adjustable cover
3	1 x 3 x 8' – door stop, latches and floor edge
3	5/8" x 4' x 8' exterior plywood – sides, roof and floor
2	6" heavy duty strap hinge – calf door front
2	4" heavy duty strap hinge – removal cleaning door
2	2" light duty hinges – heater door
1	1/8" expanded metal 3' x 3' – fan, light cover and heater compartment door
1	2'-2" x 3'-8" plastic coated perforated metal or slat floor
2	3/4" dia. x 2'-6" galvanized pipe – lifting handles
4	3/8" x 1 1/2" x 10" strap iron – lifting bar handle support
1	12" x 12" plexiglass window – calf door front
	Sufficient screws, nails and bolts for construction
	<u>Electrical Components</u>
2	SPST (single pole single throw) switch
1	Electrical handy box
2	Weather proof electrical boxes with weather proof switch covers
1	Duplex outlet (125 volt - 15 ampere)
1	Duplex cover
1	Porcelain light fixture, 60 watt bulb
	No. 14 UF cable
	Wire duplex outlet to one switch for heater and fan
	Wire light to separate switch
1	1500 watt electric heater with internal fan and thermostat
1	250 cfm fan

MINNESOTA EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

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Agricultural Engineering
D.W. Bates, J.F. Anderson, and R.D. Appleman

Building and Managing Calf Hutches

Calf death losses exceeding 20 percent are common in many dairy herds. These losses result from pneumonia and other respiratory diseases caused or aggravated by an unhealthful environment in poorly ventilated dairy or calf barns.

In some herds, calf losses are so great that sufficient herd replacements cannot be raised. Moreover, surviving animals may have permanently damaged lungs due to pneumonia. The productivity of these animals may be severely limited when they enter the milking herd.

Many dairymen have solved their calf raising problems by abandoning their "warm" facilities and raising calves in calf hutches. Experience has shown that calves which are well supervised and housed in properly designed hutches do well. The primary objection to the use of calf hutches is usually made during adverse weather conditions by the calf caretaker who must feed the calves twice daily. Using calf hutches in about the northern one-quarter of Minnesota during the coldest winter months is not recommended.

Construction

The calf hutch illustrated below can be built easily from 3½ sheets of plywood and 2x4's for framing members. It is 8 feet long and 4 feet wide. The front height is 4 feet and the back height 3 feet 6 inches to allow for drainage of rain and snowmelt away from the open front. Side panels are beveled accordingly. Cut them to a length of 7 feet 10 inches to allow the roof to overhang the back panel. The design is such that the sides can be assembled on the ground. Note that the 2x4 supports are on the outside of the plywood.

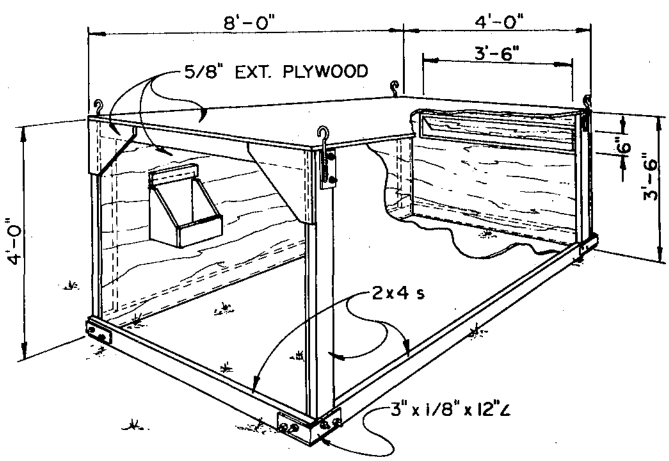
To assemble a unit, place the two sides in the proper vertical position. Temporarily nail the front 2x4, which is in contact with the ground, to the vertical supports. Place the upper 2x4 between the vertical supports and nail it in position.

Next, nail the front plywood braces, which have a side and top length of 10 inches, into position. Then nail the back panel in place and fasten the horizontal 2x4 at ground level. Next, bolt the four angleiron braces as shown. Finally, attach the roof using #4 wood screws 1½ inches long spaced about 8 inches apart. For extra strength, use a 2x4 at the upper edge of each panel. Hooks that project above the roof can be fastened to each corner. This facilitates moving the hutch with a front end loader using chains and spreader bars.

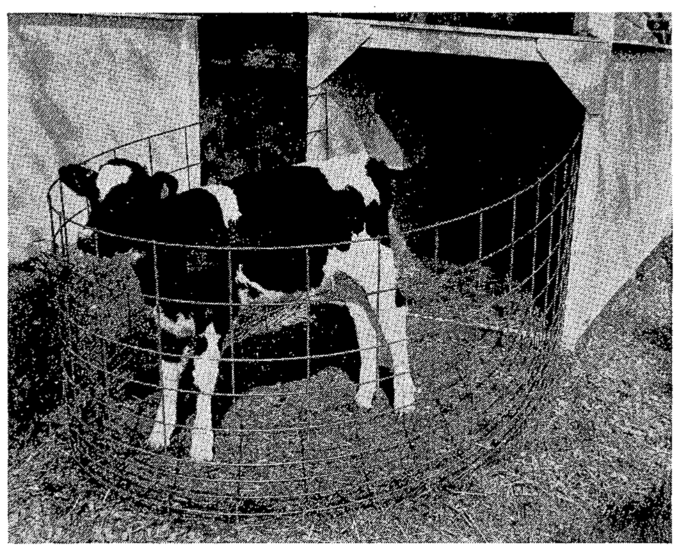
For additional summer ventilation, build a 6 inch high hinged-ventilation door that is 3 feet 6 inches wide in the back panel and 6 inches below the roof. Use trim strips to prevent air leakage and drafts in the hutch when the doors are closed in cold weather.

Location

Locate calf hutches on a well-drained site away from the barn or cow yard. If possible, take advantage of a grove of trees or other suitable windbreak. Do not locate hutches too close to any



OPEN FRONT PLYWOOD CALF HUTCH



The drawing above shows construction details for an open front plywood calf hutch. A 2x6 can be used across the base at the open front if desired as a further aid in retaining deep bedding in winter. In the accompanying photo, note the grain box on the interior wall. In fair weather, the calf spends much time outside the structure.

building that will subject them to water runoff from the building's roof. Never locate the hutches near a barn exhaust fan because disease organisms shed by chronic-recovered, pneumonia-carrier cows may be present in the air stream that could infect the calves.

When hutches are located on flat land, place at least 6 inches of gravel-fill beneath the hutches so that surface water will not flow into them. Use plenty of bedding in winter to provide a dry surface on which calves may lie down. In summer, dry gravel inside the hutch with no bedding has been shown to aid fly control. Likewise, gravel in the fenced area in front of the hutch will improve drainage and help to control flies.

Management

Good calf health begins with sanitary maternity quarters. Preferably, freshening pens should be located outside the milking barn to prevent the non-immune calf from being exposed to mature cows that may be chronic-recovered disease carriers. An alternative is to separate the pens from the main barn with a tight partition and provide a separate ventilation system for that area.

For reasons of construction and management, however, freshening pens are usually located in the barn with the milking herd and share the same environment. In this case, it is essential that the ventilation system be planned so that air movement is from the box stall toward the area occupied by the milking herd. Admit fresh air to the box stalls, but do not locate exhaust fans near the stalls. Where a solid wall is not practical, a solid partition 4-½ feet high is recommended on the sides of box stalls adjacent to permanently occupied cow stalls.

The calf should receive an adequate supply of fresh milk (colostrum) soon after birth. A first feeding of two quarts of colostrum for Holstein calves (three pints for Jerseys or Guernseys) and a similar amount at a second feeding before six hours has elapsed are recommended. The colostrum should be milked from all four of the cow's quarters since varying levels of colostrum are produced among quarters.

A navel clip should be applied to the calf's navel immediately following birth. This prevents infections from entering and causing hernias.

Space calf hutches at least 4 feet apart to provide semi-isolation for young calves. Place the newborn calf in a clean, well-bedded hutch soon after it has been dried off. This isolation from both older animals and other calves is an excellent way to prevent the spread of disease.

A calf hutch that is entirely open at the front provides a variety of micro-climates for the calf. Only during periods of extremely bad weather will the calf be observed in the back portion of the hutch. On cold, sunny days, calves normally will lie immediately inside the hutch opening. On warm winter days, they spend much of their time in the outside pen.

Never close the front of a calf hutch. Closing the hutch front prevents adequate air exchange. This causes moisture expired in the breath of the animal and the moisture excreted in the urine and feces to remain within the hutch. The result is a contaminated environment that predisposes the calf to sickness. Frost will form on the walls and ceilings of the hutch under low temperature conditions. When this melts, the bedding and particularly the haircoat of the calf become wet, increasing heat loss. Consequently, the animal experiences a drop in body temperature and may die unless properly managed.

Make sure the back portion of the hutch is tightly constructed to prevent air movement through it in winter. This will reduce draft on the animal and minimize snow drifting into the hutch. If the hutch is used in summer, it is desirable either to elevate the rear of the hutch slightly or to install a small door in the rear near the ceiling. This can be opened to allow air movement through the hutch for greater calf comfort and to improve fly control.

Calves in hutches are isolated from each other as well as older animals. They are not isolated, however, from cats on a farm. Cats can carry disease organisms that cause calf pneumonia (Pasturella sp., etc.). Cats should not be allowed contact with calves under any circumstances.

Feeding Milk

Proper nutrition is essential. In warm weather, the milk portion of the ration should be 10 percent of the calf's body weight and divided between morning and evening feedings. During extended periods of extremely cold weather, a young calf's energy requirements increase markedly when housed outside. Then the milk ration may need to be doubled and divided among three feedings. The temperature of the milk should be about 105° F *when fed to the calf.* Increase the ration gradually as the cold weather intensifies and persists. A rapid increase in food intake may cause nutritional scours, which can predispose an animal to other disease conditions.

The preferred ration for young calves is whole milk. If milk replacer is used, it should be a high-quality replacer with 20 to 22 percent protein, 20 percent fat, less than 0.25 percent fiber, and contain *no antibiotics*. Iodine should be limited to 2 milligrams per head per day.

Calves housed outside should be examined daily during feeding. To do this, place your hand on the rib cage and loin area to make sure the calf is maintaining a sufficient covering of muscle and fat and is properly hydrated. An animal's haircoat grows rapidly during cold weather, and its apparent body condition can be misleading. Aggressiveness during milk consumption is a good measure of calf health.

Starvation brings about a drop in body temperature (hypothermia) with a drop in blood sugars (hypoglycemia) and, unless corrected, quickly results in disease and death. A daily assessment of the calf's condition can quickly detect an inadequate ration.

Summary

Properly managed calf hutches provide a healthy environment for young animals compared to most other calf raising facilities. They are an effective way to reduce environmentally related disease. More labor may be required to use them but this is offset by improved calf health. Move hutches to a new location once or twice a year. Clean and sanitize a hutch after each use when weather permits, including tipping them on end for exposure to the sun.

Reduced calf death losses plus a resulting increase in numbers of healthy herd replacements that have an improved production potential can increase profits on your dairy farm.

Bill of Materials

No.	Description
4	⅝"x 4'x 8' B-C ext plywood
3	2 x 4 x 8'-0"
5	2 x 4 x 4'-0"
16 ft	42" high welded wire fencing
1 lb	6d galv nails
4	3" x ⅛" x 12" anglebraces
32	⅜" x 3" bolts
4	3/16" x 2½"x 9" plates
4	½" x 6" eye bolts

D.W. Bates is a professor and extension agricultural engineer, J.F. Anderson is a professor of veterinary medicine, and R.D. Appleman is a professor and extension dairyman.

Issued in furtherance of cooperative extension work in agriculture and home economics acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Patrick J. Borich, Dean and Director of Minnesota Extension Service, University of Minnesota, St. Paul, Minnesota 55108.

AG-FO-0416
Revised 1984

BUILDING A SUPER CALF HUTCH

Donald W. Bates, professor and extension agricultural engineer
John F. Anderson, professor of large animal clinical sciences

Raising healthy dairy calves in individual calf hutches is becoming a common practice. Calf growth rate in these units is excellent when nutrition and management are at a high level. At about eight weeks of age, however, calves outgrow hutches and alternative housing is required. Then difficulty may be encountered because there is generally a lack of suitable housing for calves of this age. They are often moved to an "old chicken house," to a lean-to along the side of the barn, or to a pole building with older animals. Competition for feed and group status results in stress. Exposure to infections from larger animals during this time often precipitates disease. Healthy calves introduced into undesirable conditions after being raised in the semi-isolation of a calf hutch may contract pneumonia, and some may die. Surviving calves often don't do well. However, the greatest loss is that the animals never will produce up to their genetic potential. Chronic disease can severely limit genetic capability.

The super calf hutch has been developed specifically to provide housing for the calf after eight weeks of age. It also prevents exposure to more mature animals maintained under a variety of conditions. The capacity of this unit is eight calves to an age of about five months. In this structure the animals are exposed only to each other. Thus, it allows a small number of calves to be acclimated to group housing and they experience less stress as a result.

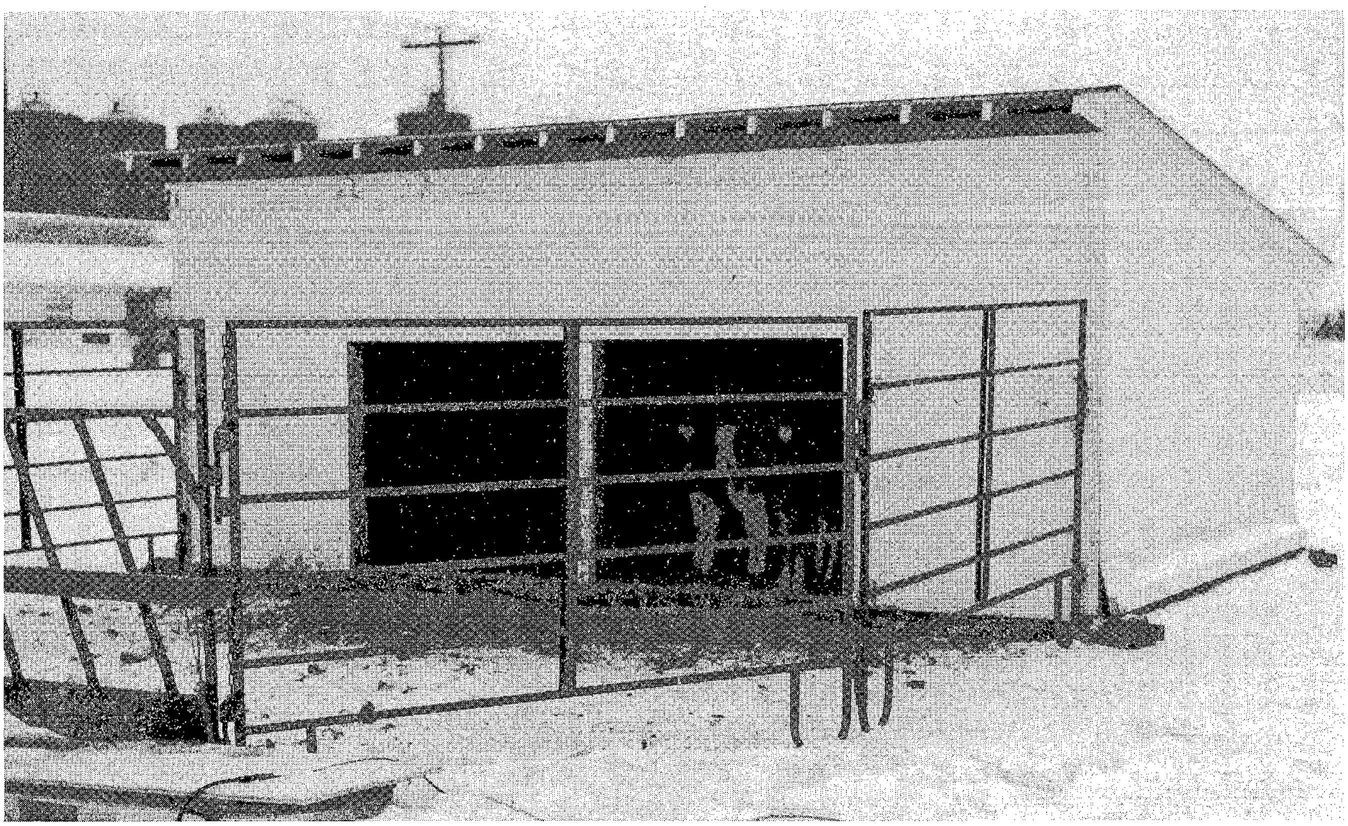
Movable for cleaning

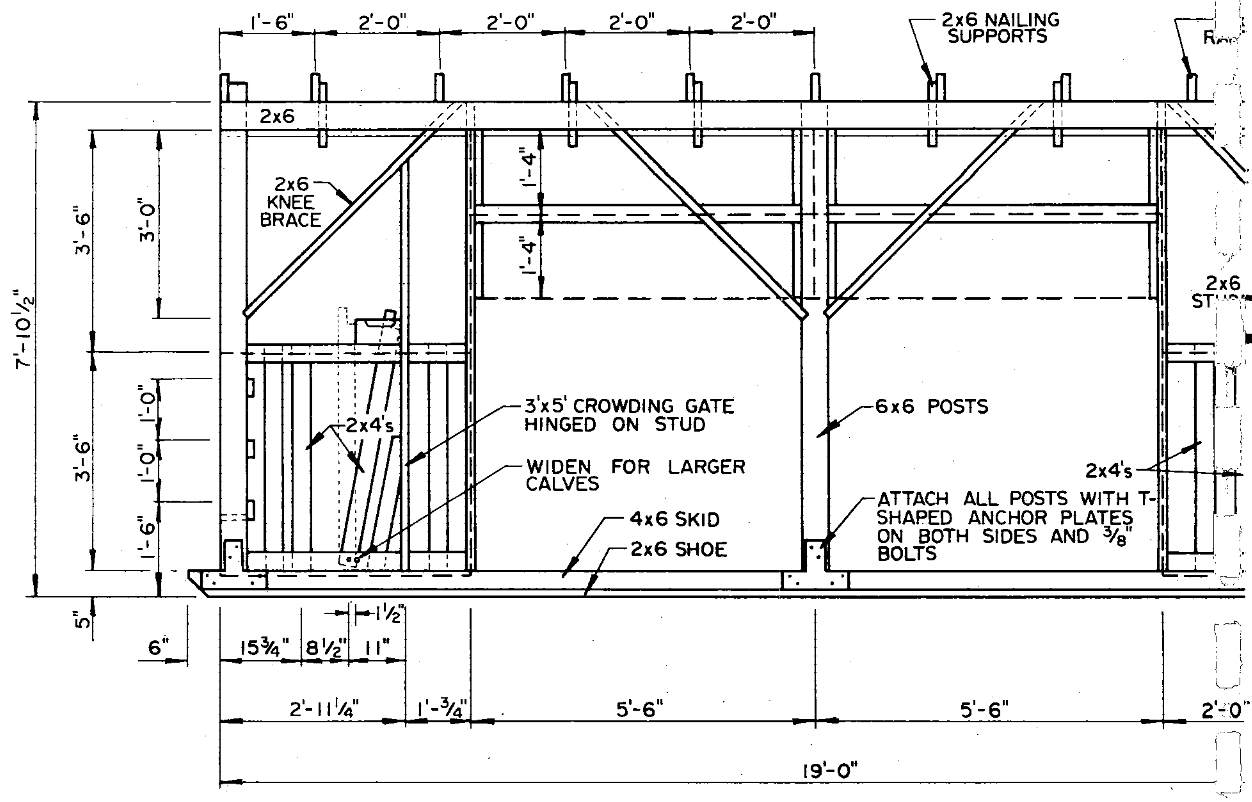
The super calf hutch is a 12 x 19-foot semi-portable unit built on skids. It is of frame construction, covered with plywood and has a shed roof. Straw or other suitable bedding material is required, as in the calf hutch.

Year-round use

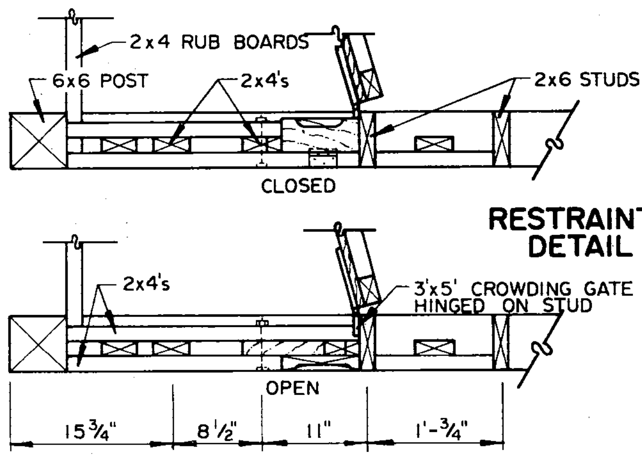
Because the super hutch is intended for year-round use, its design must provide for sub-zero temperatures on a windy day as well as the hot summer day when there is little air movement. To accomplish this, adjustable openings are provided in both the front and back walls. The space between the rafters at the front is intended to be left open except under extremely adverse conditions where partial closing may be necessary as good judgment may dictate. The front wall of the building is nearly eight feet high.

When cleaning the super calf hutch, the end panel at right is swung upward and the building is pulled in the opposite direction with a tractor. Exposed manure is then easily removed with a loader. Coarse screen may be required on both sides of the opening between the rafters, to prevent birds from nesting. The water tank at the lower left has an electric heater.





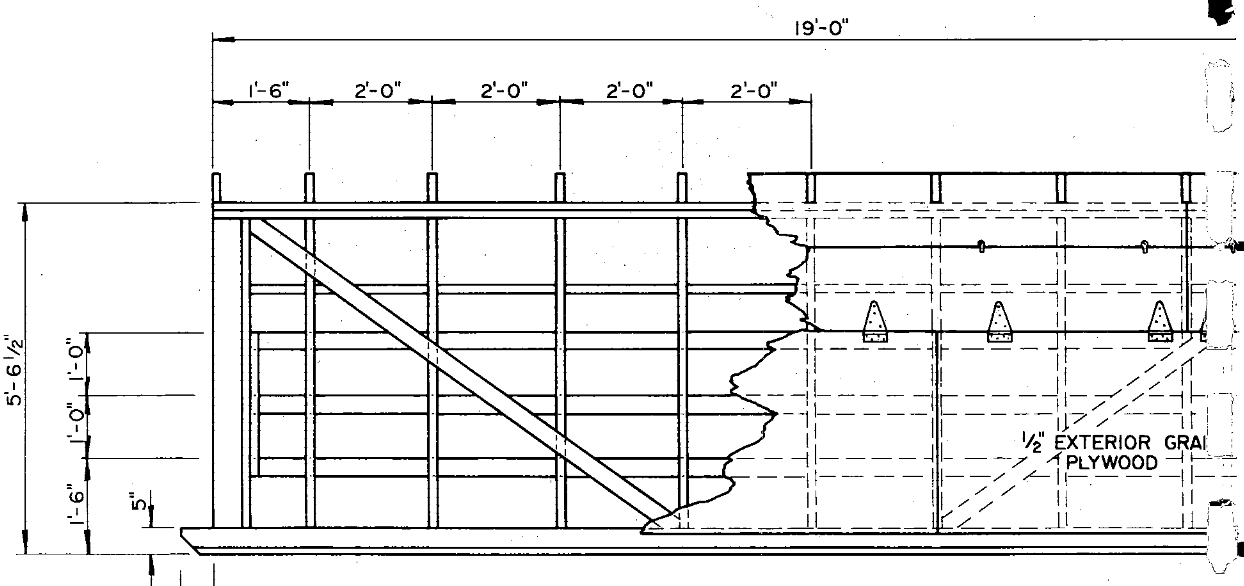
FRONT VIEW



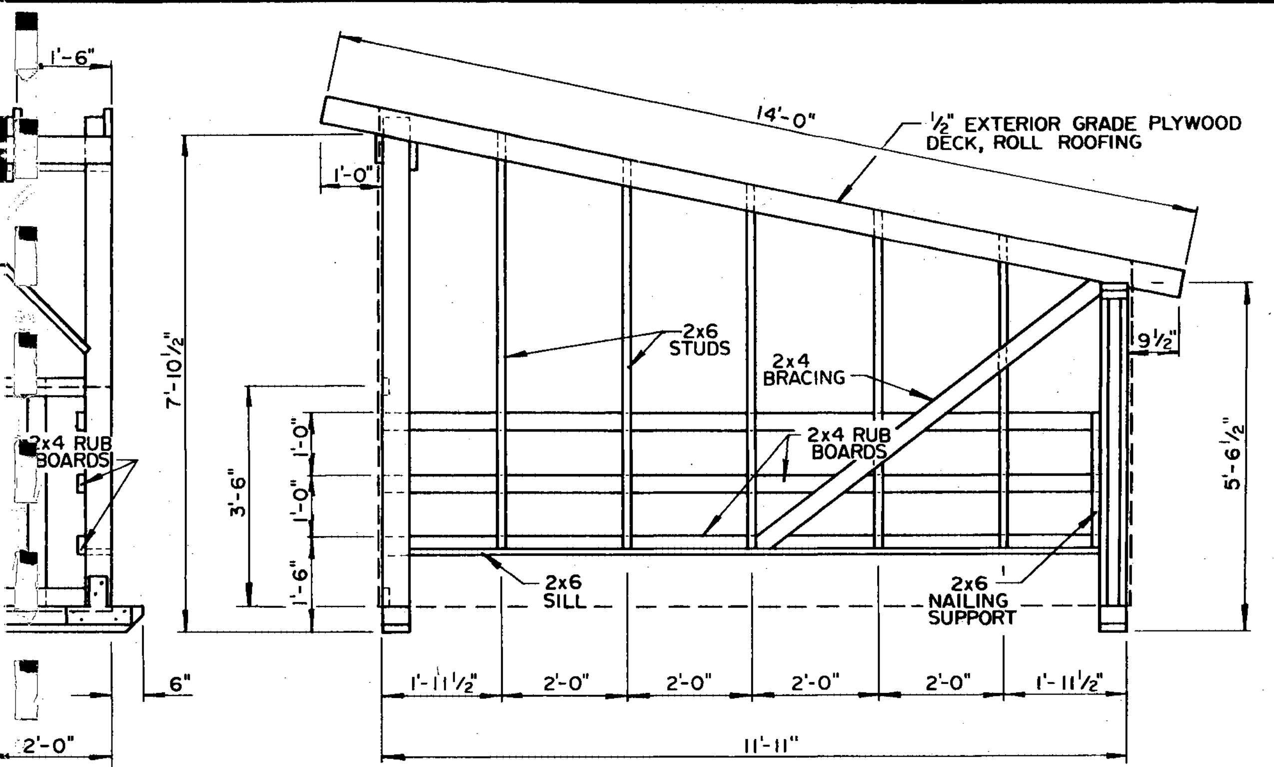
RESTRAINT DETAIL

NOTES:

1. ADJUST FRONT AND REAR HINGED PA...
2. FOR EXPOSED LOCATIONS PARTIAL C... FRONT MAY BE NECESSARY IN WINT...
3. PROVIDE OUTSIDE FENCED AREA FOR F...
4. SWING UP END PANEL THEN MOVE B...
5. CAPACITY - 8 CALVES TO ABOUT 400...
6. ANCHOR AGAINST HIGH WINDS.
7. CLOSE BOTH SIDES OF OPENINGS BET... KEEP BIRDS FROM NESTING BETWEE...



REAR VIEW

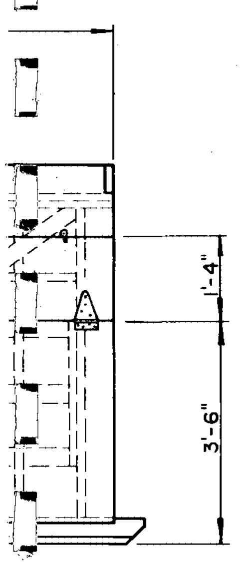


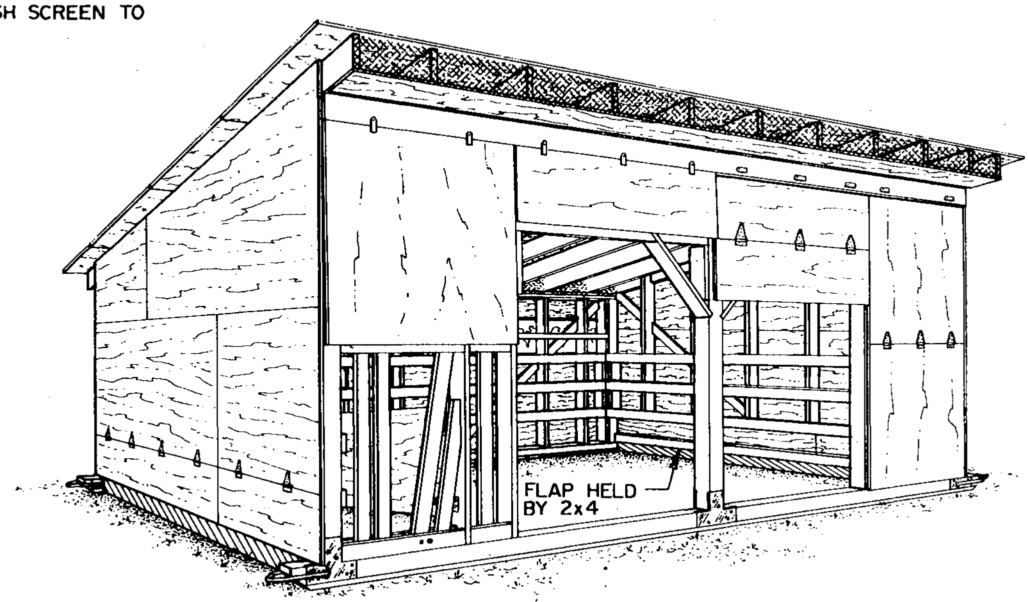
SIDE VIEW

ORDING TO WEATHER CONDITIONS.
PACE BETWEEN RAFTERS AT

AND WATERING.
WITH TRACTOR TO CLEAN.

RAFTERS WITH ½" MESH SCREEN TO





PERSPECTIVE

UNIVERSITY OF MINNESOTA EXTENSION AGRICULTURAL ENGINEERING		
SUPER CALF HUTCH	Dsgn. by D.W. Bates and J.F. Anderson	
	Drwn. by JN	1 of 1
	Date Revised 8/83	
	Scale ½" = 1'-0"	

The front can be completely closed at both ends from a distance of four feet toward the center. The front opens at the bottom to a height of 3′6″ by swinging up hinged panels. When closed in winter, the panels eliminate the common problem of a north or quartering wind tending to whip into the building from around the corners of the open front. They also provide protection from the south when a strong wind might otherwise blow into this quite shallow open building. The center section also has hinged doors 1′4″ high to restrict the height of the center opening. In the closed position the front opening is 5′2″ and in the open position, 6′6″. At the back there is a downward swinging hinged door 16 inches deep and the full length of the building. This is to be open in summer as required for increased air movement and must be tightly closed in winter. Remember that wall openings need to be adjusted according to weather conditions and that careful observation is required.

Calf restraint

An important feature of the super calf hutch is the restraint unit. This provides safety for both the animal and the caretaker during processing (vaccination, branding, castration, etc.) procedures. A small wooden stanchion is built into the left front of the building. This stanchion is uncovered when the horizontally hinged front panel is lifted. It is always exposed in summer because the front doors of the building are then fully open.

A swinging plywood panel is attached to a front post. This is hinged vertically to form a chute which directs the calf into the wooden stanchion. The calf being processed is thus firmly restrained between the gate and the outside wall. Safety is also provided for the caretaker who stands outside the gate.

From the veterinarian's standpoint, the restraint feature permits safe, easy, efficient handling of animals. Attention then needs to be devoted only to the procedure being performed.

Feeding is done outside of the super hutch in a small yard. This area may be formed using movable steel gates or other portable fencing material. The feedbunk and the water supply are accessible to the animals through the fence.

Careful thought must be given to the winter water supply. A good approach is to provide a permanent single-compartment, frost-free waterer positioned centrally for each super hutch. This location allows access from either of the two settings for the building as it is moved back and forth for cleaning.

The yard must be paved for permanent use to avoid mud accumulation. The area on which the super hutch rests may be covered with gravel, but paving is preferable. Be sure to raise the ground level on which the super hutches are located so that rain and snowmelt water will drain away. A concrete slab 28 x 44 feet, crowned about 4 inches at the front of the super hutch with respect to its length is desirable for each housing unit.

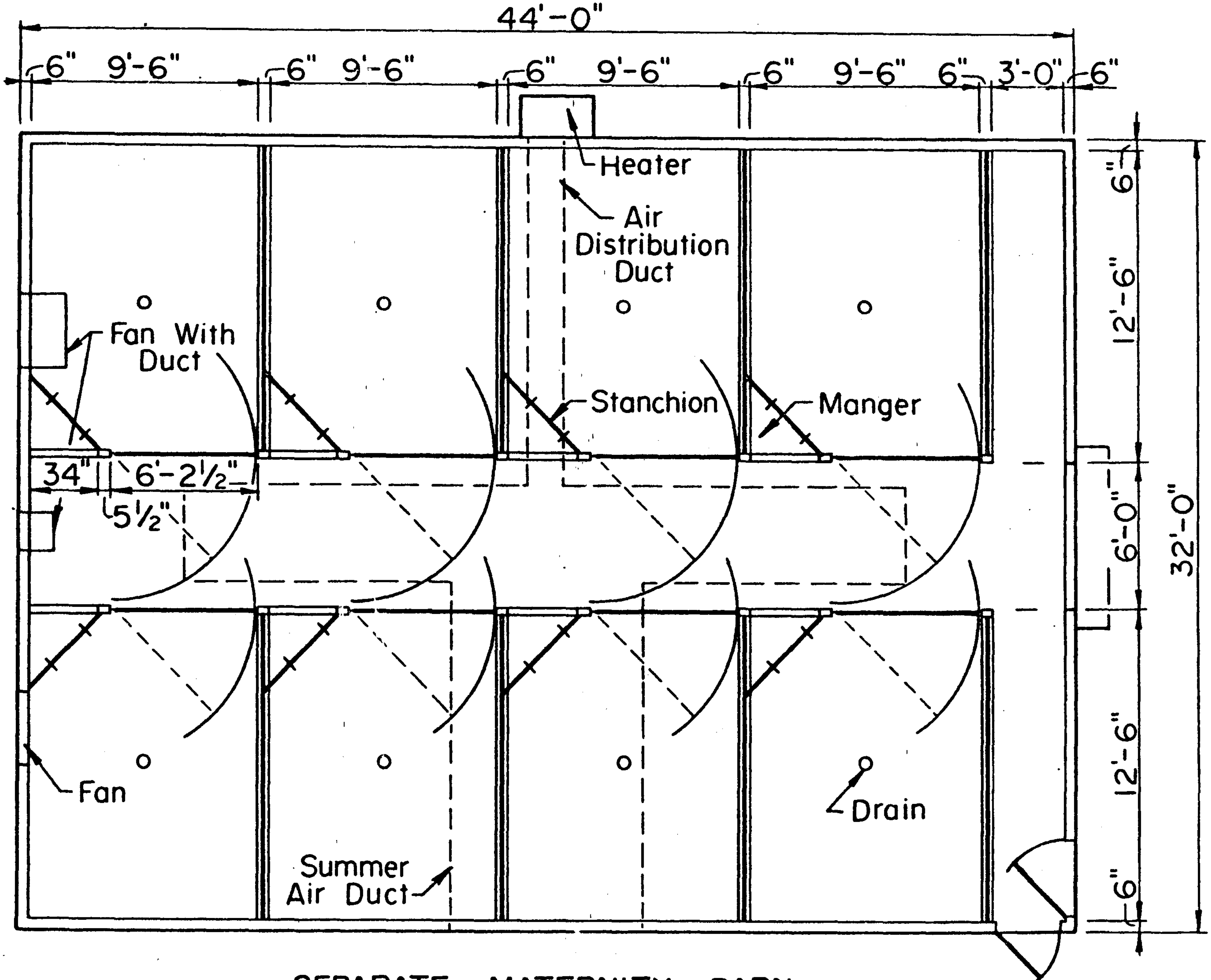
Hinged doors are located at the base of the end walls running the full width of the building. These doors are intended for use only when the unit is cleaned. One end door is fastened open and the super hutch is pulled in the opposite direction with a tractor—a procedure prohibited only when the super hutch is completely frozen in place during winter. The manure is left in a pile for easy removal with a front end loader. The sills are raised so that the end opening is unobstructed when either door is opened.

Super calf hutches perform well in winter. They have been tested under severe weather conditions with temperatures ranging as low as –20°F with a wind chill of –90°F. The calves in three experimental units remained in good physical condition. There was no evidence of damage to their health. You may find one or more super calf hutches to be a practical way of providing housing after calves have outgrown individual calf hutches. These structures provide excellent housing conditions for animals up to five months of age. Succeeding moves should be to naturally ventilated buildings of suitable design essential for animal health. This permits the calves' continued growth and development thereby enabling the animals to enter your milking herd at full genetic potential.

Approximate Bill of Materials

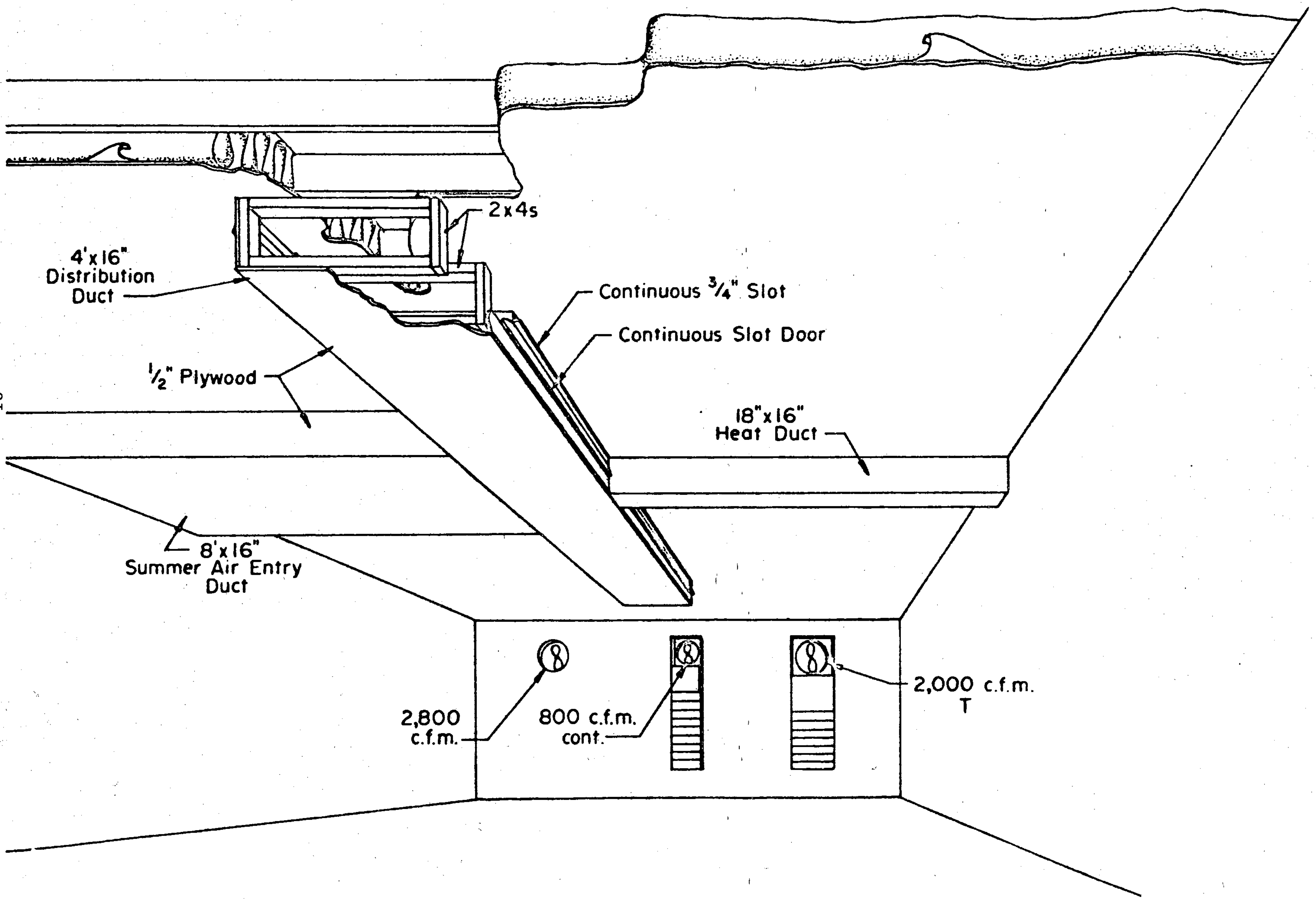
Number	Description
2	2 x 6 20 ft. rafter girts
11	2 x 6 14 ft. rafters
1	2 x 6 14 ft. split for crowding gate bracing
2	2 x 6 12 ft. sill plates
4	2 x 6 10 ft. skid plates
13	2 x 6 8 ft. studs, top plates
28	2 x 6 6 ft. nail supports, center door supports, studs, knee bracing
4	2 x 4 12 ft. flaps and rub boards on side
4	2 x 4 10 ft. backwall braces and rub boards
16	2 x 4 8 ft. center door supports, stanchion, wall front, rub boards, sidewall braces
9	2 x 4 6 ft. jamb, stanchion support, rub boards
2	2 x 2 10 ft. board across rear vent
3	6 x 6 8 ft. posts
2	4 x 6 20 ft. skids
26	4 x 8 x ½″ exterior grade plywood for sheathing, roof decking, crowding gate
40	6″ heavy-duty T-hinges
1	⅜″ bolt for stanchion hinge
20	door fasteners—vent doors
6	inverted T-shaped anchor plate ¼″ x 3½″ x 11½″ (length) x 9½″ (height)
4	¼ x 3 x 5″ metal plates for back side on skids to weld metal bar
26	⅜″ x 6½″ bolts—T-metal plates, back metal plates
4	rolls of roll roofing
1	6″ wide roll ½″ mesh screen, 76′ long
2	9″ x 11′ x 6″ canvas flap
14	3″ door hooks for closing front panels and opening manure removal openings
4	¾″ diameter bars 29″ long bent and welded to metal plates for pulling
	sufficient nails for construction

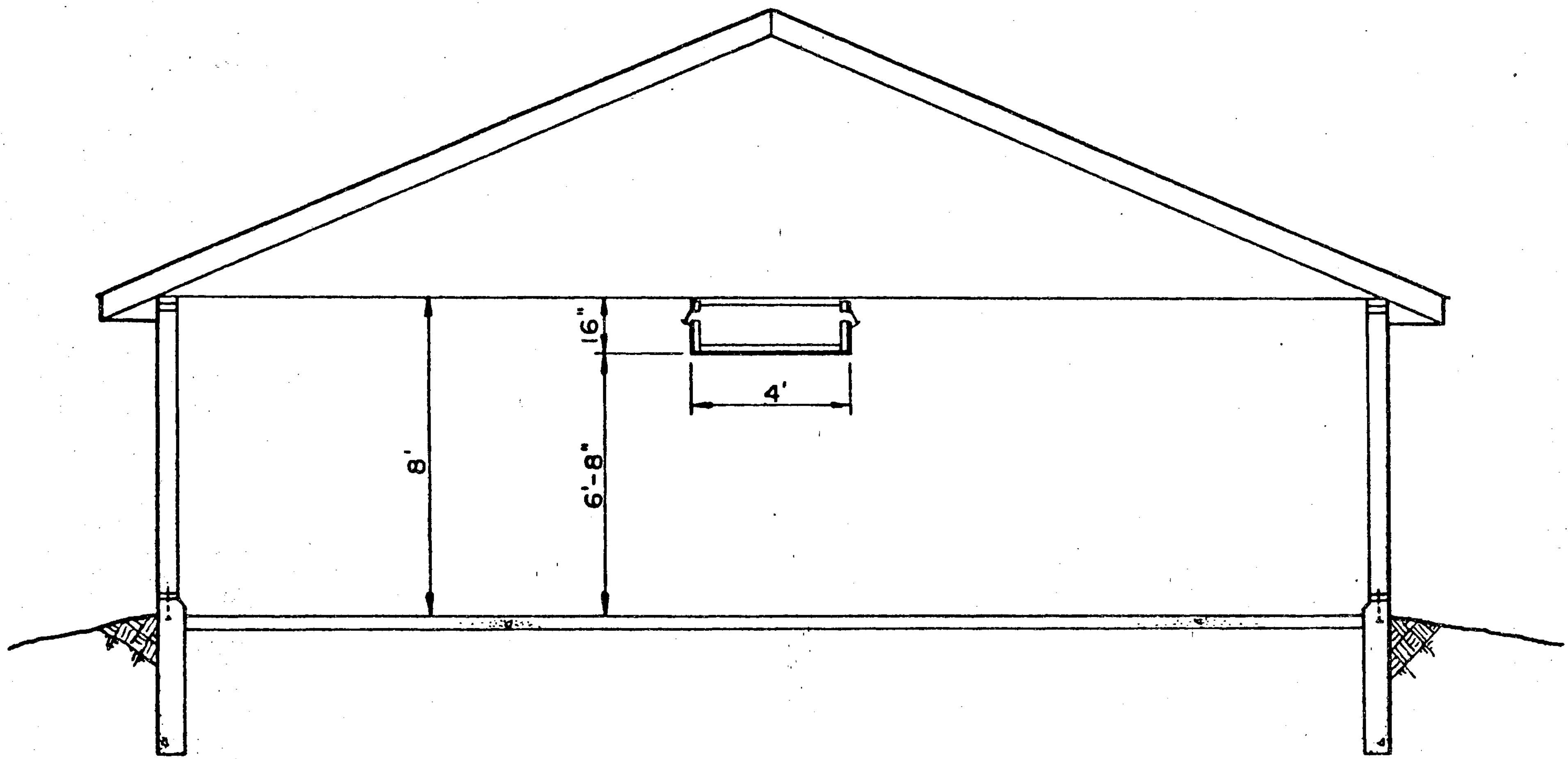
Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Patrick J. Borich, Acting Dean and Director of Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55108. The University of Minnesota, including the Agricultural Extension Service, is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, religion, color, sex, national origin, handicap, age, or veteran status.



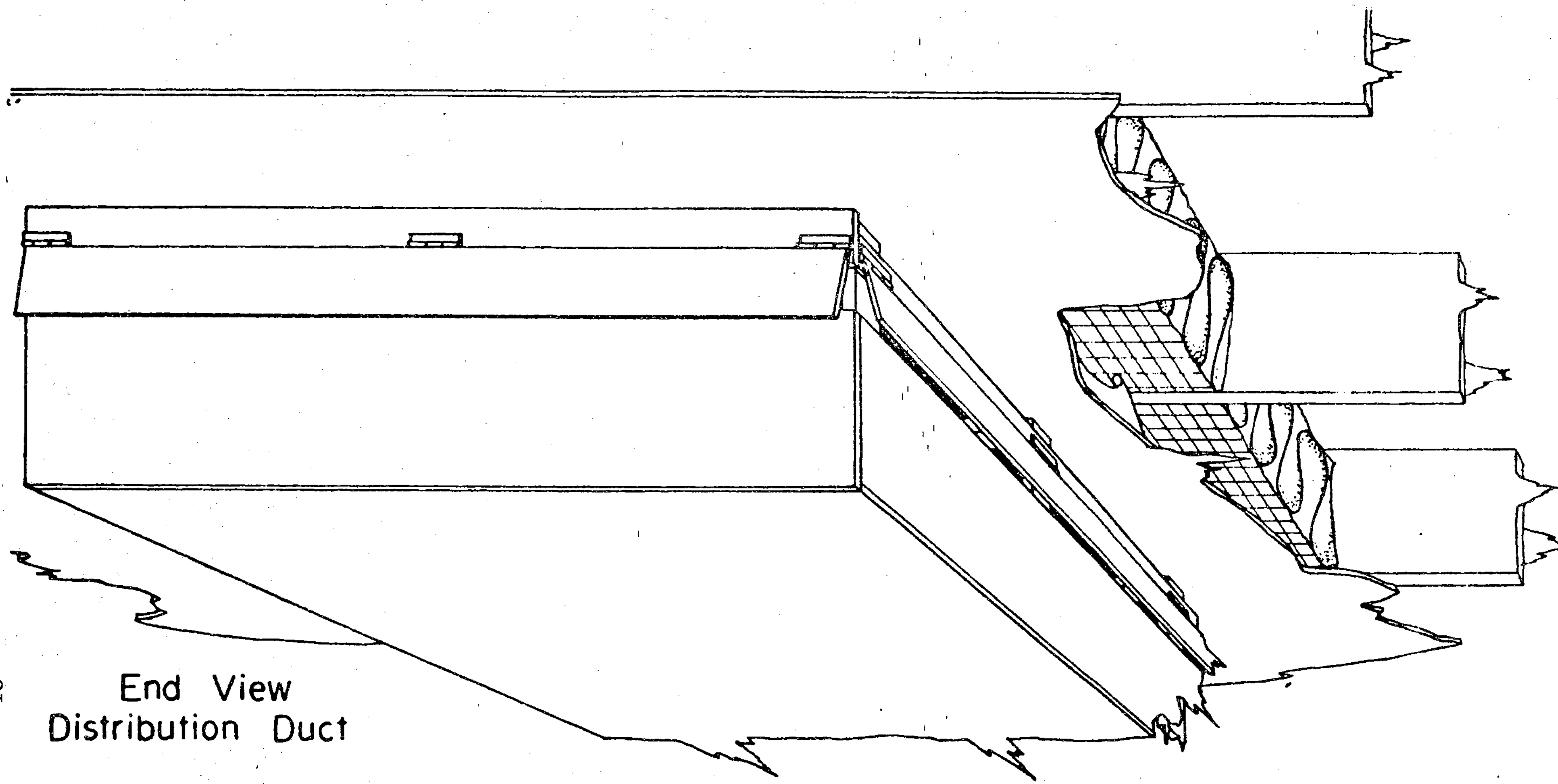
SEPARATE MATERNITY BARN & VENTILATION SYSTEM

Designed by
D.W. Bates - J.F. Anderson
University of Minnesota 4-79

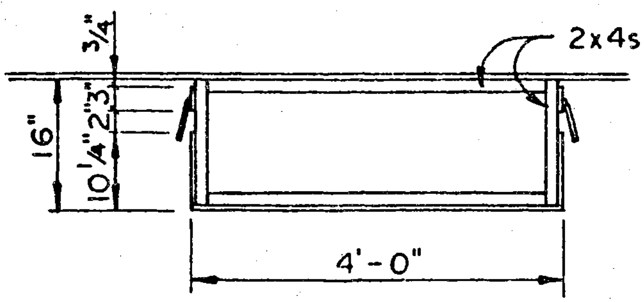

2x4s
4'x16"
Distribution
Duct
Continuous 3/4" Slot
Continuous Slot Door
1/2" Plywood
18"x16"
Heat Duct
8'x16"
Summer Air Entry
Duct
2,800
c.f.m.
800 c.f.m.
cont.
2,000 c.f.m.
T



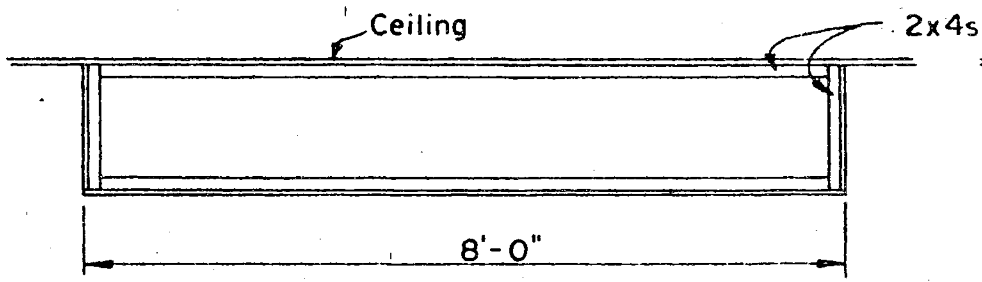
Section A-A



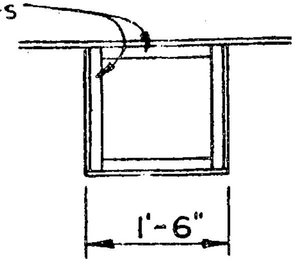
End View
Distribution Duct



Cross Section
Distribution Duct



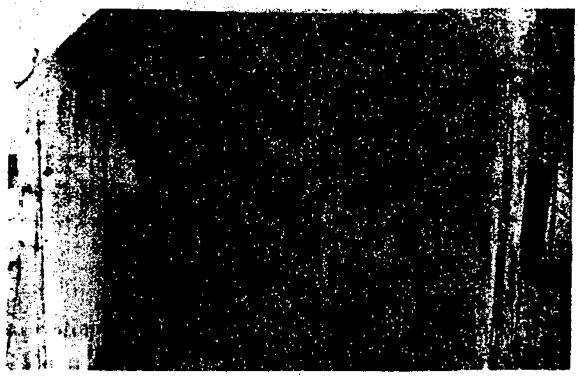
Cross Section
Summer Air Entry
Duct



Cross Section
Heat Duct

You can control flies around calf hutches

by John F. Anderson, D.V.M., Donald W. Bates, P.E. and Ben Zweber



A 6-INCH DOOR in the back of hutches provides ventilation and helps control flies. Bedding with sand eliminates breeding sites.

CALVES often are born in the same facility housing the milking herd. This exposes calves to large numbers of nonpathogenic and pathogenic organisms before they receive colostrum. A maternity facility which is separated from the herd is necessary to minimize this exposure. This area should be ventilated properly and designed for easy cleaning and disinfection.

Immediately following birth and the application of a navel clip, the calf should receive 2 quarts of clean colostrum which has been collected from all of the cow's quarters. In addition, the calf should receive 2 quarts of colostrum again at 6, 12 and 18 hours.

As soon as possible following birth when its hair coat is dry, place the calf in a clean calf hutch. The location is important.

Never place calf hutches on the side of the dairy barn in which exhaust fans are installed. If there is no other location available, be absolutely certain that the calf hutch is located at least 100 feet from the barn with the rear of the hutch toward the barn.

If hutches must be adjacent to an outside yard occupied by cows, you should have a 7-foot-high barrier wall between the calves and the older animals to reduce exposure potential. The calf hutches may need to be sheltered on the winter prevailing wind side of the hutch location as well to help prevent snow accumulation.

During winter, face hutches south to receive maximum sunlight. An alternative direction is east. However, hutches never should face west or north because of prevailing winter winds.

It's important to maintain a dry environment. Calf hutches are maintained more easily on a concrete slab with proper elevation and slope.

Authors Anderson and Bates are a professor of veterinary science and former extension agricultural engineer, respectively, at the University of Minnesota. Zweber is a dairy farmer at Elko, Minn.

The slab should be crowned with respect to the front of the hutch. Slope the outside run one way about ⅛ inch per foot, and slope the hutch the opposite way. If you don't have a concrete slab, elevate hutches on 6 inches or more of gravel to keep away runoff.

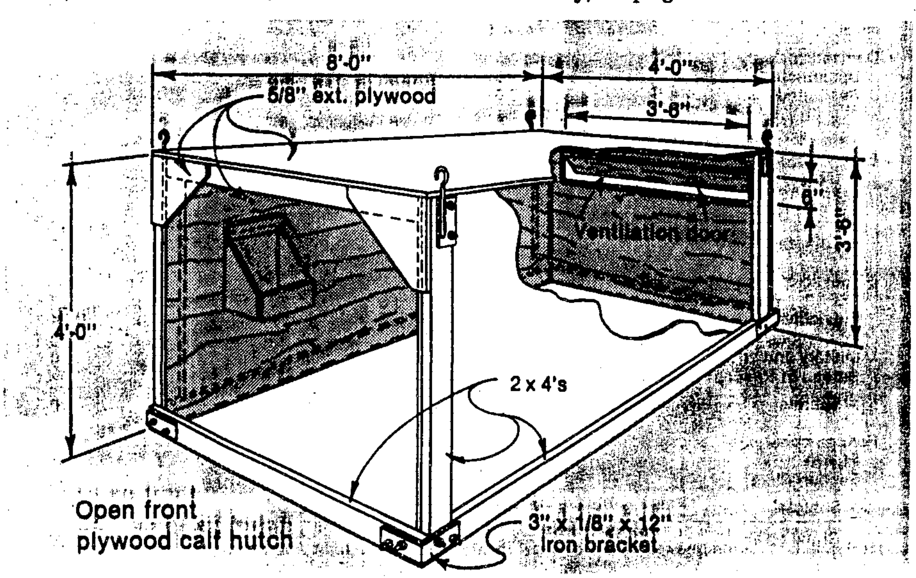
During winter, use an insulating 4-inch base beneath the bedding in the hutch. This can be dry corncobs, wood shavings, shredded cornstalks or a combination of these. Spread a bale of dry straw on this base before a new calf is placed into the hutch.

Maintaining a dry environment still is essential during summer, but then straw complicates fly control. Manure and urine mixed with bedding provide ideal breeding conditions for flies. Amazing increases in fly populations occur rapidly. Anyone who has entered calf hutches at night is well aware of fly numbers and the fact that they cling to the ceiling of the hutch where little or no air is moving.

To improve ventilation and discourage flies, install a 6-inch horizontal door beneath the roof at the rear extending the full width of a plywood hutch. This door should be hinged at the top to keep out rain when the door is open.

In addition, this door must be sealed during winter to prevent air movement through the hutch. Hypothermia and hypoglycemia in the calf can occur more rapidly if this door is not sealed completely. This seal can be accomplished with a wooden strip inside the hutch which the door closes against. An alternative is to apply a wooden strip to the bottom of the door on the outside. A third method is to caulk the door opening during winter.

The ideal bedding material during summer is 4 inches of washed sand. This provides a soft bed for the calf, and it also allows moisture to drain away, keeping the interior of the hutch dry. As a result, very little organic material is present. This markedly reduces fly numbers by eliminating breeding areas.



Do not use pit-run gravel with stones since this causes joint injuries and arthritis. Also, avoid Class 5 gravel, which has clay added for road building, because it packs readily and prevents urine and moisture in manure from draining away.

Do not use sand from sand blasting operations! It is very fine and packs quickly, preventing drainage. Often, it also contains high levels of lead from paint and hydrocarbons.

Crushed limestone does not work well since it also packs readily. It also causes joint injury and arthritis because of its sharpness.

It's important to control fly numbers to keep calves healthy and growing well. Flies are not only a constant irritant, but they have been shown to transmit infectious diseases caused by both bacterial and viral agents.

Baits can help . . .

Fly bait has been used effectively for some time, especially following a reduction in fly numbers because of bedding with sand. Be sure to keep fly bait away from young children. Also, don't allow calves to consume it in feed or water accidentally.

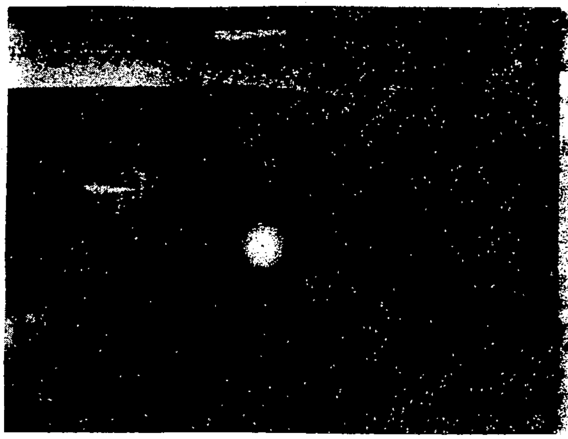
Insecticide ear tags work well if flies have not become resistant to the insecticide. In young calves, place one tag near the bottom of the calf's left ear. This allows the center of the ear to be used for calf identification tattoos if these are used.

Do not place insecticide tags in the calf's right ear because your veterinarian needs this ear free for the placement of a brucellosis vaccination tattoo. If your veterinarian suggests using a second insecticide ear tag in the calf's right ear, let him place the tag when he vaccinates the calf for brucellosis. He can prevent obliteration of the recently placed official vaccination tattoo.

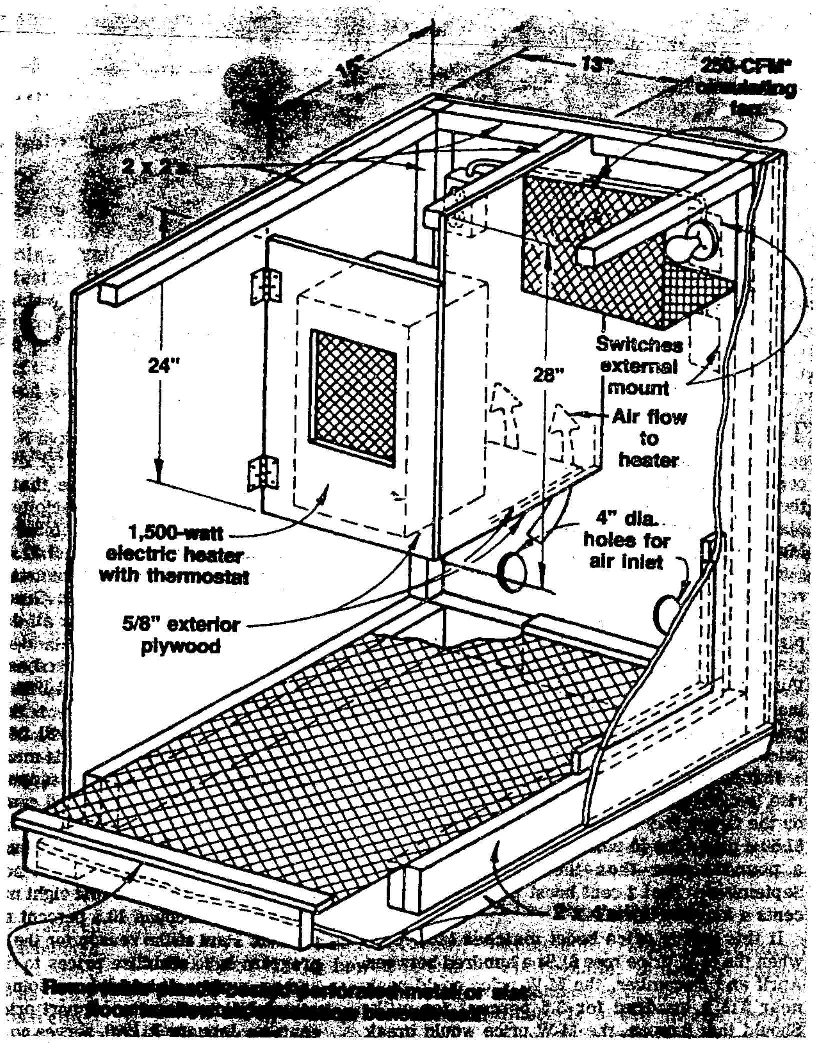
Approved residual fly sprays are beneficial when applied to the interior of hutches. Many of these products (synthetic pyrethrens) are approved for livestock housing and will be effective for up to eight weeks when they are sheltered from the rain. An ideal time to apply these sprays is after the hutch is cleaned with a power washer between calves.

Tip the hutch up on its back end, wash it out and disinfect thoroughly. After the hutch is dry, spray with residual insecticide and return it to its normal position on the ground. The hutch then should be placed on a new site adjacent to where it stood previously. This minimizes exposure to organisms from the calf which had occupied the hutch.

Fly control is part of a total animal health care program. Good health is not accidental. It is the result of an organized set of procedures designed to prevent disease and enable cattle to grow and produce to their potential.



WARMING BOXES are 4 feet high, 4 feet wide and 2-1/2 feet deep. They can be used either indoors or outdoors to warm up and dry off a calf born under cold, wet conditions. Heat is supplied by electric heater.



Warming boxes can save calves

These "incubators" are used temporarily to provide a good environment for calves immediately after birth. Coupled with proper use of colostrum, they can play a big role in eliminating disease.

by D.W. Bates and J.F. Anderson

Regardless of the type of housing you have, calves often are born in hostile environments, especially when suitable maternity pens are not available. Calves born under poor conditions are subject to stress and disease.

Infectious organisms enter the calf either through its mouth or unprotected navel. Clinical studies have shown that, if a newborn calf ingests manure before getting colostrum, there is less chance that the calf will absorb protective colostral antibodies.

We developed the calf-warming box to provide a portable, temporary facility which enables you to take the calf from unsanitary surroundings. Place the calf in the warming box as soon as possible following birth. You still need to use navel clips or dip the navel in iodine.

Prevents chilling . . .

One benefit of the calf-warming box is the prevention of chilling. This reduces the risk of low body temperature and low blood glucose due to adverse conditions. Colostrum absorption is limited in cold-stressed calves.

That is why it often is desirable to remove a calf from its surroundings at birth as quickly as possible and place it in a warm environment temporarily where it can be dried quickly and subjected to minimal stress.

Instead of drying a mucus-covered calf, try washing it with warm water before placing it in the warming box. Dry the calf completely after the first feeding of warm colostrum.

Herds in which Johne's disease (paratuberculosis) has been diagnosed especially benefit from a warming box. In those herds, calves should be removed from their dams immediately. Then the calf should receive two quarts of pasteurized colostrum immediately following birth and at 6, 12 and 18 hours later. When removed from the warming box, the calf should be placed in a clean calf hutch and bedded with adequate straw in winter or washed sand in summer.

We first developed warming box plans for beef cow-calf operations where calves often are born during severe weather and require special treatment. They were used widely. We learned that beef calves should be left in the box for no more than five hours or their dams may not reclaim them. However, dairy calves may be left in for a day or more as conditions dictate.

Heat is supplied by a thermostatically controlled electric heater having an integral circulating fan, such as that used in a 1,500-watt milk house heater. Provide an additional 250 cfm circulating fan for air movement to speed up drying of a wet calf or warm more quickly one that is chilled.

We suggest a plastic-covered, expanded-metal raised floor to allow warm air to circulate beneath the calf to accelerate drying and prevent the calf from lying in its own manure and urine. A hinged door at the end of the box opposite the heater allows easy removal of the raised floor for cleaning and permits thorough cleaning and disinfection of the entire unit.

What users say . . .

"The warming box insures fast and thorough drying of newborn calves," says Burton Peterson who farms with his sons in Rice County, Minn. They say that even a calf lying on a dry mat of straw will be damp on its belly.

"The warming box is nice to have when conditions are not ideal," according to Willard Emery who also farms with his sons in Goodhue County. The box is very helpful if you overlook getting a cow into the maternity barn, he says.

Get better start . . .

"Calves get a better start using the warming box, especially in winter," report Brian, Curt and Key Emery, also of Goodhue County. They believe that a calf can get set back as much as one month in growth rate if it gets sick. That makes the box important in preventing exposure to disease and stress.

A detailed plan for a calf-warming box is available from the Hoard's Dairyman Plan Service. Use the coupon below. Each individual plan includes a complete bill of materials and operating instructions.

Please send me a copy of Plan 788, the calf-warming box. I have enclosed $2 postpaid.

Name

Address

City State Zip

The authors are a former extension agricultural engineer and a professor of large animal clinical sciences, respectively, at the University of Minnesota.

EFFECTS OF HEAT STRESS ON PRODUCTION, HEALTH AND REPRODUCTION OF DAIRY CATTLE

J.K. Shearer DVM, MS.
Associate Professor
Extension Veterinarian

Department of Large Animal Clinical Sciences
College of Veterinary Medicine
University of Florida
Gainesville, Florida 32607

The combined effects of high ambient air temperature, relative humidity, and solar radiation have profound effects on milk yield, growth, reproduction, and cow health. In the lactating cow, total body heat load is significantly escalated by an increase in metabolically-derived heat associated with milk production. Whenever heat gain is greater than heat loss body temperature rises, heat stress results and performance is proportionally reduced.

EFFECTS OF PREPARTUM HEAT STRESS

Considering the increase in internally-derived body heat from the higher metabolic rate associated with milk production it is not surprising that the lactating cow is particularly sensitive to heat stress. The rapid decline in feed intake and milk yield during periods of thermal stress are readily apparent. Consequently, much of the attention in heat stress management is (and has been) focused on the lactating cow. Reality is that the effects of thermal stress on cows in late gestation are just as devastating, if not more so. High environmental temperatures during late pregnancy alter blood flow and maternal-fetal hormone concentrations resulting in lower birth weight of calves and reduced milk yield in the subsequent lactation.[1,2,3,4,5]

Gestation length of the bovine ranges from 270-292 days and is divided into three periods: 1) the period of the ovum, blastula, or early embryo (from fertilization to day 10-12), 2) the period of the embryo and organogenesis (from day 10 to day 45), and 3) the period of the fetus and fetal growth (from day 45 to parturition).[6] In terms of greatest sensitivity to elevated temperatures, the period of the early embryo and last trimester of the fetal growth period are the most important.

Logically, uterine growth precedes placental growth, which in turn, precedes growth of the fetus. Approximately 60% of bovine fetal growth occurs during the last 90 days of pregnancy. Near term the unborn calf is increasing in weight by 1.1 to 1.5 pounds per day.[7] Prolonged exposure to high temperatures during this crucial period can have dramatic effects on placental and fetal growth as well as fetal viability. In a study by Bell, et al. chronic exposure to elevated temperatures during gestation in ewes retarded placental growth by 54%, fetal growth by 17%, and was responsible for fetal death in 3 of 6 heat stressed ewes.[8] Head et al. found similar effects on placental growth of dairy cattle where summer heat stress significantly reduced placental dry weights.[9]

Effects of prepartum heat stress on calf birth weight are reported in 2 studies by Collier et al. and 1 by Wolfenson et al. Using a large data set comprised of 975 Holstein calves born over 23 years, Collier et al. found a seasonal trend in calf birth weight observing that calves born during mid to late summer weighed 10% less than those born during the winter months.[2] This effect on birth weight was reaffirmed in a follow-up study in which prepartum cows were housed in either a shade or no shade group. Mean birth weight of calves born to cows assigned to a shade group was 87.3 lbs. compared to 80.5 lbs. (8% reduction in weight) for calves assigned to a no shade group (Table 1).[3] No difference in length of gestation was detected between the shade and no shade group. A similar study in Israel by Wolfenson et al., observed that calf birth weight increased an average of 5.7 lbs. for calves born to cows assigned prepartum to a shade structure equipped with sprinklers and fans for cooling.[4] Calf birth weight differences in the latter study were greatest for cows in their fourth or greater lactation.

Milk yield was related to calf birth weight in all three studies; larger calf birth weights were associated with higher subsequent milk yield. In the shade/no-shade experiment by Collier et al., postpartum 305-day predicted milk yield was reduced by 12% in the group with no access to shade prepartum (Table 1).[3] Cooling prepartum increased daily milk production by an average of 7.7 lbs. through 150 days postpartum in the study by Wolfenson et al.[4] Similar results were reported from a study on three dairies in Central Saudi Arabia where prepartum cooling of cows from two of three herds studied significantly increased milk production at peak lactation over cows not cooled prepartum.[5] On the basis of these observations, it's clear that strategies for cooling cows during the prepartum period should be a high priority.

EFFECTS OF PERIPARTUM HEAT STRESS

The process of labor and delivery is an arduous task for the cow under any circumstances but particularly so when complicated by intense solar radiation, elevated ambient air temperature, and high humidity. Cows calving during daylight hours without the benefit of shade for protection from solar radiation are especially subject to hyperthermia, heat stroke, and possibly dystocia. The problem is not uncommon to Florida dairymen in the spring when northern heifers close to parturition are imported as herd replacements to Florida dairies. They normally arrive with thick haircoats and often have difficulty acclimating to hot weather.[10] Under such circumstances these animals are particularly vulnerable to hyperthermia or heat stroke. These animals can become rapidly distressed and if unnoticed eventually collapse and progress to a comatose state that ultimately ends in death.

Field observations of pregnant ewes exposed to chronic heat stress indicate that such conditions often lead to the delivery of small lambs with poor viability.[11,12] This would appear to be the case in cattle as well, however, specific data on the relationship between heat stress and neonatal viability are limited. Mortality data from a Florida dairy for calves which died within 24 hours of birth are displyed in Table 2. Overall mortality of calves near parturition was 6.1%. This agrees with Bellows et al., which states that approximately 6.4% of calves die near parturition.[13] Of those that die near parturition most (72%) die from dystocia.[14] Since several of the calves listed as stillbirths in the Florida study were likely the result of dystocia, our data would support this view. Although an association between dystocia and seasonality has not been reported, clinically, severe heat stress appears to impair or delay parturition when cows become hyperthermic. If this clinical impression is accurate heat stress on the cow at parturition may be expected to increase the likelihood of dystocia (or prolonged delivery) and consequently the rate of dystocia/slow delivery-related calf mortality.

Seasonal effects on the failure of passive transfer in calves lend further support to a negative effect of environmental stress on the calving cow and neonate. Studies on large numbers of calves in Florida's subtropical climate have found that the concentration of serum immunoglobulins in neonates 2-10 days of age is highest during the winter months of January through March and lowest during the summer months of July and August.[15,16] There are at least 2 possible explanations for the observed seasonal effect on rates of passive transfer in warm climates. First, an Arizona study that found an increase in serum corticosteroids from heat stressed neonates which was suggested to be responsible for a reduction in permeability of the small intestine to immunoglobulin absorption by calves.[17] Secondly, a study of colostral immunoglobulin content at the first postpartum milking which suggested a reduction in the natural suckling response during periods of peak heat and environmental stress.[18] In contrast, the pattern of immunoglobulin absorption in temperate or cooler climates is poorer during winter months and improved during the more moderate summer months.[19] It would appear that factors associated with environmental stress may negatively influence passive transfer in calves by physical as well as physiological means.

In addition to dystocia, one of the most frequent calving-related problems is retained placenta. Specific causes for retained fetal membranes are numerous but nutritional imbalances, fat cow syndrome, peripartum disease, twinning, and dystocia are considered some of the more important redisposing factors. Incidence rates of 10-12% are generally accepted as normal. However, frequency is higher whenever gestation is shorter than normal (a common consequence of induced parturition). A seasonal increase in the incidence of retained placenta associated with heat stress has been reported. Incidence of retained fetal membranes and metritis increased from an average of 12% during moderate weather to 24% during the hotter stressful period of May through September.[20] Days open was lengthened by 32 days for cows having retained placenta/metritis and by 24 days as a result of calving during the warmer months. Length of gestation for cows with retained fetal membranes was 5.25 days shorter than for cows which did not retain their placentas. In contrast, a Florida study by Martin et al. failed to show an effect of season on fetal membrane retention, however, days to first service, days open, and services per conception were all extended by the occurrence of retained placenta.[21]

EFFECTS OF POSTPARTUM HEAT STRESS

Milk Yield

The environmental temperature range most conducive to optimal milk production is between 41 and 77°F. The lower limit (lower critical temperature) of this range is flexible and dependent upon age, diet, and other factors. On the other hand, in the lactating dairy cow the upper limit (upper critical temperature) is fairly rigid such that feed intake and milk production are measureably affected whenever temperatures approach 78-80°F. At a temperature of 104°F feed intake is reported to be only 60% of normal intake rates.[22] A Florida study in which cows were housed in either a shade or no-shade environment found that cows with no shade consumed 56% less feed during daytime hours. Cows in this study compensated some over night by increasing feed consumption by 19% compared with cows in shade. Overall, feed intake was reduced by 13% for cows with no-shade compared to cows having access to a shade structure.

Thatcher et al. observed an increase of 9.6% in 4% fat corrected milk for cows maintained in an air-conditioned environment compared to cows housed under natural heat-stressing environmental conditions.[23] Another study comparing the effect of shade verses no-shade on lactational performance found an increase of 10.7% for cows housed and fed under a shade structure compared with no shade controls.[24] Finally, Schneider, et al. observed a 23% improvement in daily feed intake and a 19% increase in milk production cows in shade compared to cows with no shade.[25] Clearly, feed intake and therefore lactational performance are improved by the attenuation of heat stress.

Udder Health

Somatic cell counts and incidence of clinical mastitis in the southeast region increase during the summer months.[26,27,28] These observations suggest that heat stress may amplify susceptibility to intramammary infection by decreasing host resistance and/or increasing host exposure to pathogens created by conditions which favor their growth and propagation in the cow's environment.

Evidence for a direct effect of elevated temperature on the immune system is limited and based primarily on in vitro studies. An indirect effect on immunity may occur as a result of decreased feed intake and consequently deficient uptake of essential nutrients important to optimal immune function. Vitamin E and the selenium-containing enzyme, glutathione peroxidase, are antioxidants which protect body cells and tissues from oxidative attack by free radicals released during the respiratory burst associated with bacterial killing in neutrophils and macrophages. Neutrophils obtained from cows deficient in Vitamin E and selenium had reduced intracellular bacterial killing.[29] A study by Smith et al. found that the prevalence of intramammary infection at calving in heifers supplemented with Vitamin E and selenium was reduced by 42% compared to unsupplemented controls.[30]

Postpartum Reproductive Performance

Heat stress negatively impacts conception rate, estrus detection efficiency, and embryo survival/development. The resultant seasonal depression in reproductive performance is one of the most serious problems of the dairy industry in the southern United States as well as subtropical and tropical countries throughout the world.

Conception Rates

Conception rates plummet during periods of extreme high temperature and humidity. Rates as low as 10% following artificial insemination have been recorded.[31] As a result some dairies choose to avoid breeding cows during the hotter months. Badinga et al., in a large study involving 6,555 inseminations in a Florida dairy over a 3-year period with 3 breeds represented, made several key observations.[32] Heifers had higher conception rates (47%) compared to lactating cows (32%). The discrepancy in conception rate for heifers verses cows is most likely due to the inability of lactating cows to maintain normal body temperature during periods of heat stress because of an increase in metabolically-derived heat associated with milk production. The most significant decline in conception rate occurred during the summer months of June through August and recovery was slow requiring an additional 2 months before achieving pre-heat stress rates (See Figure 1). The decrease in conception rate was accelerated when environmental temperatures rose above 86°F. Differences by breed were: Jersey 45%, Brown Swiss 41%, and Holstein 39% and reflect differences in milk production and thermoregulatory responses to heat stress.

The most common causes of reproductive inefficiency in dairy herds are: 1) inadequate estrus detection, or the absence of expressed estrus and 2) infertility, some of which is due to embryonic mortality.[33] Heat stress does not prevent the occurrence of normal estrus cycles. It does, however, amplify the problem of heat detection by reducing the length of the estrus period (from 18 hours down to 10 hours) and lowering the intensity of estrus behavior.[34] Thatcher et al. documented the magnitude of this effect on estrus detection in a large commercial dairy noting an increase in percent of undetected heats from normal annual rates of 66% to 80% during the hot summer months of July and August.[35] The combined effects of poor conception and reduced heat detection efficiency have a devastating on overall reproductive performance in dairy herds.

Early Embryo Survival and Development

Several studies have demonstrated that early stage embryos are especially sensitive to high environmental temperature.[36,37,38,39] Heat stress occurring on the day of estrus or within 1-7 days post-estrus is particularly deleterious to embryo survival. Putney et al. studied the effect of acute short-term heat stress (107°F for 10 hours beginning with the onset of estrus) prior to ovulation in superovulated heifers. Heifers in the heat stress and thermoneutral group were maintained post-treatment in thermoneutral conditions until embryo collection and evaluation on day 7 following insemination. The objective was to determine the incidence of embryo abnormalities and mortality resulting from short-term heat stress on the day of estrus. Only 12% of the embryos recovered from heat stressed heifers were considered normal compared with 68.4% of the embryos from heifers assigned to the thermoneutral group (75°F). Furthermore, an appreciably higher level of embryo death occurred in the heat-stressed group.[39] A second study to determine the effect of thermal stress occurring from ovulation through day 7 had similar results with only 20.7% of embryos collected from stressed heifers being categorized as normal compared with 51.5% from thermoneutral controls.[40] Consequently, dairy cattle need to be protected from heat stress on the day of insemination and for at least 7 days following fertilization in order to avoid heat-induced embryo loss.

In an effort to circumvent problems associated with heat stress on early embryos, Putney et al. devised a scheme involving embryo transfer to bypass the period of greatest susceptibility.[41] Selected embryos collected from superovulated heifers on day 7 post insemination were nonsurgically transferred to 113 synchronized lactating Holstein dairy cows. An additional 524 lactating cows were artificially inseminated for comparison purposes. Pregnancy rates for the embryo transfer group were 47.6% and 29.2% compared with 18.0% and 13.5% for the artificial insemination group at day 21 (determined by milk progesterone) and 40, respectively (See Table 2). This study supports the concept of extreme sensitivity of the early embryo to heat stress, and in addition points to a possible solution. As technological advances continue in the art and science of embryo transfer it is presumed that this may become one of the tools or options for dealing with the problem of early embryonic mortality associated with heat stress.

Susceptibility of the embryo beyond day 7 post insemination appears to be substantially lower. Biggers et al. studied the effects of high temperature on embryos between days 8 and 16 and observed that although pregnancy rates were not affected there was a trend toward higher embryonic mortality in heat stressed cattle.[42] It is worthy of note that there appeared to be significant embryo loss (embryo transfer group reduced by 18.4% from day 21 to day 40) beyond 21 days in the study by Putney et al. as well. Therefore, further study into the effects of heat stress on later stage embryos is warranted.

SUMMARY

Heat stress, whether it occurs in the prepartum, peripartum, or postpartum period can have drastic affects on performance. In late gestation chronic hyperthermia can reduce calf birth weights, and decrease milk production in the subsequent lactation. Clinical observation suggests that under conditions of severe heat stress during the peripartum period, the natural course of parturition may be prolonged. This may result in the delivery of calves of suboptimal viability based on seasonal reductions in passive transfer and natural suckling by neonates. Finally, effects of heat stress on lactational and reproductive performance can be particularly devastating. Optimal milk production requires feeding and management practices which will minimize internal heat production in combination with facilities which will prevent excessive heat load from the environment while assisting the dairy cow to dissipate surplus body heat. Heat stress markedly reduces conception rate and increases embryonic mortality. Since the early embryo is most susceptible to heat stress, the incorporation of cooling strategies for cows on the day of estrus and for 7 days thereafter would likely decrease embryo loss due to hyperthermia.

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Table 1. Effect of heat stress prepartum on calf birth weight and maternal milk yield postpartum (adapted from Collier et al.).[3]

Trait	Shade	No Shade	Difference (%)
Calf birth weight	87.3[a]	80.5	6.8 (8%)
100-d milk yield (lbs)	5,878.4	5,623.2	255.2 (4%)
305-d milk yield[b] (lbs)	14,867.6	13,085.6	1782.0 (12%)

[a] significant ($P < .05$)

[b] 305-d predicted yield adjusted for age, month of calving, and Estimated Relative Producing Ability (ERPA).

Table 2. Pregnancy rates of embryo receipient and artificially inseminated lactating dairy cows, determined by milk progesterone concentrations (Day 21 post-estrus) and by rectal palpation (40 - 60 days post-estrus). Adapted from Putney et al.[41]

	Pregnancy Rate %			
	Embryo Transfer Group		Artificial Insemination Group	
Number	Day 21	Day 40 (n)	Day 21	Day 40 (n)
637	47.6	29.2 (113)	18.0	13.5 (524)

Day 21 pregnancy rate difference significant ($p< 0.001$).
Day 40 to 60 pregnancy rate difference significant ($p< 0.001$).

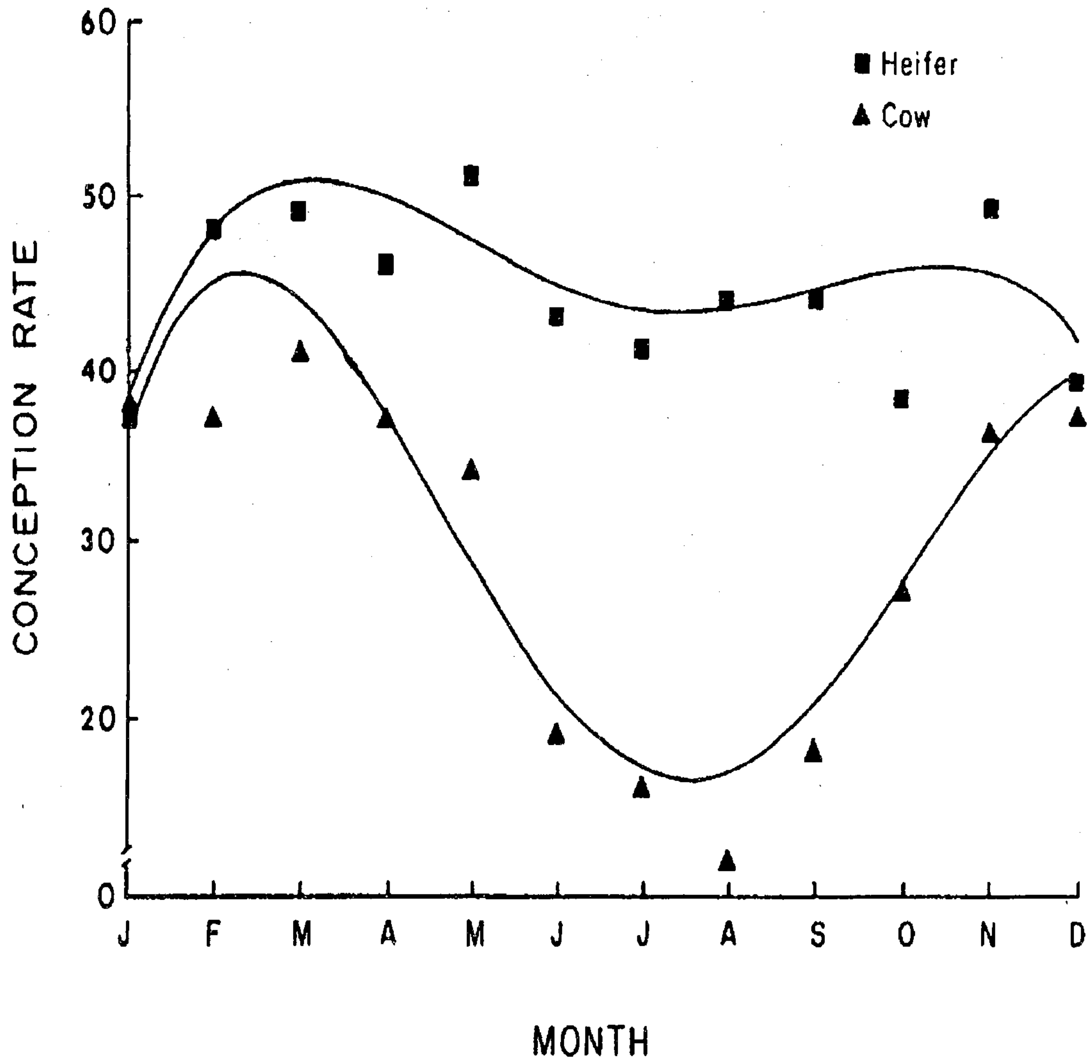

Figure 1. Least square means for monthly conception rates (%) in heifers and cows, unadjusted for environmental effects. (Adapted from Badinga et al.)[32]

REMODELING EXISTING FACILITIES: CHANGES FOR THE BETTER

William G. Bickert, Ph.D.
Agricultural Engineering Department
Michigan State University
East Lansing, MI 48823-1323

INTRODUCTION

The buildings and equipment which comprise a dairy operation are there to facilitate the job of caring for the animals on the farm. Labor requirements, flow of animals and materials, pollution control, future expansion and management requirements are important considerations in design.

Planning for new construction or remodeling of these dairy facilities must be based on a sound management plan. The plan sets forth all factors related to nutrition, health and growth as well as all other activities of the dairy farm operation. The buildings and equipment which comprise dairy facilities are merely tools which allow essential tasks prescribed by the management plan to be carried out on a regular basis. Haphazard planning or impulsive acquisition of buildings or equipment will only lead to facilities which impede implementation of updated management plans and hinder future development and expansion.

Providing environments that meet the needs of the animals being housed is important in design, also. While many of these needs may be obvious, the degree to which they are satisfied may vary widely. This may be due to a lack of understanding as to just what the needs of the animals are when it comes to establishing and maintaining their environment. For example, a warm barn for calves may have excessively high relative humidity due a lack of understanding of both the needs of the calves and the design and operation of the ventilation system. Or, it may result from an improper ordering of the priorities being used for design. For example, the establishment of the environment in a barn may place the needs of people and equipment ahead of the needs of the animals which are to be housed, oftentimes to the detriment of the animals.

A discussion of some of the considerations for meeting the needs of dairy animals follows.

FREE STALL DESIGN

Free stalls must provide a clean, comfortable lying space for cows. In addition, free stalls should allow cows to rise and lie down in a natural fashion.

As a cow rises from a lying position in the pasture, she lunges forward, transferring her weight forward to help raise her hindquarters, much like a springboard action. To achieve this natural movement, a cow must have sufficient space to thrust her head forward as shown in Figure 1 (Cermak et al., 1983). If she cannot lunge forward, it is more difficult for her to rise on her hind legs. If restricted too much, she rises front legs first, like a horse.

Free stalls usually do not provide enough rising space. Length is limited to reduce defecations in the rear of the stall, important to good udder health. But the limited length restricts the forward thrust of the head and makes it more difficult for the cow to rise. The lower rail of the stall partition may also injure cows as they lie and rise. Injuries may occur in the hip and pelvic regions as cows strike or rest against lower rails or rear stall supports.

An improved free stall partition (Figure 2) makes it easier for cows to lie and rise and increases the likelihood that cows will use the stalls. The new partition has more space beneath the lower rail at the front of the stall. As a cow begins to rise, she uses this space as she lunges forward, turning and thrusting her head into the next stall space. The lower rail is also higher at the rear to reduce potential injuries to hips and legs. Reduced stall maintenance is an added benefit as a result of the cow having less interaction with the stall partition.

The stall is supported at the front and has a neck rail which, for typical dairy cows, is positioned 40 inches above the stall base at the front and 18 inches from the stall front for a stall that is seven feet long.

If cows don't use free stalls, there's usually a reason related to stall design, construction or maintenance. Partition design affects the cow's ability to lie and rise and the occurrence of injuries, as has been discussed. Stall length, stall width and the condition of the stall bed are important also.

Stall fronts and partitions should be open sufficiently to allow ventilating air to move through the stall space. Good bedding is always essential, not only to improve comfort but to absorb moisture accumulating on the stall surface as well.

Proper free stall management includes daily inspection and removal of wet bedding and manure, in addition to periodic additions of dry bedding. If free stalls are neglected and contain excessive moisture or accumulations of manure, bacterial populations may exceed critical values, markedly increasing infection rate of the udder.

VENTILATION

Ventilation of livestock facilities is essential to maintaining a proper environment for the animals being housed. A complete discussion of environment would include a multitude of related factors that affect animals and their growths; emphasis here is on the need for ventilation as related to the thermal environment, air quality and moisture control. Of course, providing a proper environment is only one component of a successful animal rearing program.

Providing the proper environment for an animal amounts to furnishing conditions that enhance the animal's inherent ability to achieve thermoregulation and using ventilation to provide moisture control and to maintain suitable air quality. Basically, the aim is dry, relatively draft-free surroundings, especially in winter, with increased ventilation for warmer weather. Any attempt to house animals in an enclosed building with inadequate ventilation will result in excessively high humidities that complicate problems of air quality, disease transmission, and condensation; the net result will be generally unhealthy conditions.

Ventilation of livestock buildings in winter is mainly for moisture control; the primary source of moisture being the animals themselves. In summer, temperature control is of principal concern.

From the standpoint of providing for the needs of animals, problems with respect to ventilation usually originate because needs of people and equipment have been placed ahead of the needs of animals. Or, relationships between the needs of animals and the environment are not well understood.

In the first instance, problems are most evident in the winter when cold temperatures contribute to malfunctions of equipment such as mechanical bunk feeders. Or, freezing conditions cause difficulty with scraping manure. To alleviate one or more of these problems, a free stall barn, designed as a cold-enclosed, naturally-ventilated building, may have ventilation openings blocked for the purpose of increasing inside temperatures. Excessively high relative humidities are the usual result of this effort to defeat the function of the ventilation system. On the other hand, dairy animals do well if provided with properly ventilated cold barns and are kept dry and properly fed. Proper equipment selection and management can minimize the inconveniences associated with freezing weather.

In the summer, dairy cows housed in free stall barns show substantial drops in milk production during periods of hot weather. These losses may be expected to increase as even higher milk yields stress animals further. Many farmers accept the lost revenue due to this decreased production as inevitable. But this loss in milk production can be minimized through full wall ventilation, a practice which, in fact, also reduces the cost of new construction.

Cold Housing with Natural Ventilation:

Natural ventilation occurs as air pressure gradients induced by wind forces and density gradients induced by thermal forces produce flow of air through a building. Generally, thermal forces are relied upon for moisture control in winter; wind forces for temperature control in summer.

Temperatures in a cold barn can be expected to be a few degrees warmer than outside air temperature due to the heat being given off by the animals being housed. This warmed air tends to rise. To take advantage of this thermal buoyancy and its ability to move air for ventilation purposes, the ridge and the eaves of the building are left open. The air in the barn, having been heated slightly by the animals, rises, picking up moisture along the way, and leaves the barn through the open ridge. In the process, outside air is drawn in through the open eaves to replace it. This air exchange process is referred to as the stack effect and is the predominant means of providing moisture control in cold enclosed, naturally-ventilated barns.

Provide a ridge opening of 2 inches for every 10 feet of building width; e.g., a 12 inch opening for a building 60 feet wide. This open ridge acts as the air outlet for ventilation due to the stack effect. The eave openings, the air inlets, should provide an overall open area equivalent to that of the open ridge.

Ventilation and moisture problems in cold housing occur primarily because of inadequate openings. Natural ventilation requires openings in the building. The fact that rain and snow may enter these essential openings may lead producers to ignore ventilation needs and close existing openings or to provide inadequate openings in the first place.

Since ventilation in winter is primarily for moisture control, the most obvious indicator of inadequate ventilation is a severe moisture buildup, including condensation on the roof and walls. Excessive odors and animal respiratory illness may also result. Due to excessively high relative humidity, the interior of the barn may, in fact, feel cold upon entering, in spite of the fact that the inside temperature may be only slightly higher than it should be. Obviously, such a cold, damp condition is to be avoided.

Ventilation should be sufficient to keep inside temperature within 10-15°F of outside temperature in the winter. If this is not the case, check for recommended ridge and eave openings. Make sure that nothing is interfering with the stack effect which is the force for natural ventilation in the winter. A winter ventilation problem can usually be corrected by increasing openings to increase ventilation rates, possibly even taking advantage of winds by openings windows and doors. In any event, install a thermometer in the barn to make sure inside temperatures stay within the acceptable limit given above.

For buildings constructed with an open peak, remove the ridge cap. If the resultant opening is too small, follow the procedure shown in Figure 3 to realize the necessary size.

Summer ventilation depends on the wind, the main factors affecting ventilation rates due to wind being wind speed, wind direction, area of building openings and local obstructions (hills, vegetation, nearby buildings). To maximize inlet and outlet openings and to site buildings for maximum exposure to existing winds is to maximize air exchange rates due to wind forces.

Current recommendations for constructing naturally-ventilated dairy barns and other livestock buildings for summer ventilation call for large openings, typically ½ or more of the sidewall, in both sides of the building. Site selection is deemed important with recommendations calling for situating naturally-ventilated buildings on high ground for better wind exposure and away from other structures or trees.

Far too many naturally-ventilated barns do not meet current recommendations for warm weather ventilation, not only older facilities but many just completed as well. Even those buildings where recommendations are followed have unnecessarily warm environments in summer. For example, in dairy free stall barns, substantial drops in milk production are noted during periods of hot weather, especially with high producing cows. These losses may be expected to increase as even higher milk yields stress animals further.

Dairy farmers, faced with diminishing profit margins, can no longer accept lost revenue due to decreased milk production in hot weather as inevitable. On the other hand, making a cost benefit analysis, in the usual sense, is difficult since, although the adverse effect of hot weather on milk production is well-known, actual relationships have not been well-documented. Instances of cows losing 5 to 12 pounds milk production on days when temperatures exceed 86°F are not uncommon. This loss in production often continues even after the hot period has passed.

Full wall ventilation for naturally-ventilated barns in summer (Figure 4) reduces the potential for heat stress in animals, especially during periods of little wind. Basically, this means having a barn with no sidewall cladding to better utilize winds to improve warm weather environments. Obviously, some sort of cover is essential to accommodate seasonal changes in weather. However, automatic control or even frequent manual adjustment of air inlets is considered unnecessary. The dairy cow can tolerate usual diurnal fluctuations in environment and even fluctuations during the season, especially in summer.

For existing barns, accomplishing full wall ventilation involves removing existing sidewall cladding and other impediments to air movement in the sidewall. In other words, view the barn as a sun shade for summer and open the sidewalls as completely as possible. In new construction, simply stop short of installing a permanent sidewall covering.

Various materials and methods can be used to cover sidewalls for colder weather. But the simplest and cheapest method uses a fabric covering over the full sidewall. For summer, the fabric is manually rolled up as a rug and tied at every post. To close the sidewall, ties are released and the hanging curtain is then fastened in place using a vertical nailing strip at each post and horizontal nailing strips all along the bottom.

Mechanical Ventilation:

Mechanical ventilation systems are usually associated with warm housing where it is desired to maintain a relatively uniform environment throughout the winter. A warm barn is kept at a predetermined temperature in winter by good construction, careful control of the ventilating system and supplemental heat as needed. Such a barn is well insulated and is usually mechanically ventilated. Examples are tie-stall dairy barns and swine farrowing and nursery buildings.

Three levels of ventilation must be provided to accommodate seasonal changes; three fans can achieve this. The first fan provides a minimum continuous rate to assure that moisture removal takes place even under the coldest conditions. As the weather warms, the outside air picks up less moisture as it moves through the building; more air therefore must be moved to keep the relative humidity down to an acceptable level. The second fan serves this purpose. The third fan is primarily for additional summer ventilation.

FEED BARRIERS AND MANGERS

A feed barrier is the divider between the animal and the feed in a manger setting. The primary purpose of this barrier is to restrain the animal while feeding.

A post and rail barrier is usually used for fence-line feeding, as in a drive-through free stall barn. The animal reaches over a short concrete wall for feed which has been placed on a surface elevated slightly above the floor upon which the animal is standing. The rail, which defines the upper limit of this space, is made up of cable, pipe, or plank and is usually situated directly above the short wall or slightly toward the cow. This design does restrain the animal. But, in doing so, it may unnecessarily restrict the reach of the feeding animal and result in the animal exerting excessive force against the barrier.

Only a slight modification of this design, based on work by Dumelow et al. (1988), greatly improves the feeding situation for the animal (Figure 5). The rail is moved from its usual position upward and away from the animal. This modification, adaptable to existing post and rail installations as well as new construction, allows the animal to reach further while exerting less force on the barrier.

The feed surface may be elevated 2-6 inches above the cow alley in the fenceline barrier in Figure 5. Minimizing this elevation maximizes the height of the manger wall against which the cows' ration is piled. This maximizes the amount of material that can be deposited in a given feeding. Also, as discussed by Albright (1983), cows prefer mangers that offer the opportunity to eat in this natural grazing-like position as compared to eating from elevated bunks. Furthermore, behavioral activities contributing to feed wastage, such as rooting feed out of shallow, elevated bunks and feed tossing are virtually eliminated.

Eating surfaces must be smooth, clean and free from leftover feed and other debris in order to encourage feed intake and aid in the control of disease. In new construction, use high-strength concrete to prolong the condition of the manger surface used for feeding silages and other feeds which tend to etch the concrete. Or, line the manger with a resistant material such as ceramic tile. Inspect existing manger surfaces for etched conditions and exposed aggregate or worn and splintered wood and take measures to correct these conditions if they exist.

WATERERS

Recommendations for waterers, including location, size, height and number, seem to have evolved over the course of time. When considering that water is an essential nutritional ingredient and that nutrition is of utmost concern with respect to satisfying the needs of the high-producing cow, it is surprising that more research-based design data are not available and even more amazing that design guidelines for watering systems for cows rarely, if ever, include even a mention of the necessary water supply rate based on the drinking rate of a cow.

Nonetheless, minimum design guidelines at this time seem to be to provide at least one watering space or two feet of tank perimeter for every 15-20 cows. At least two waterer locations are needed for each group of cows. Provide more space and more locations if two-year-olds are housed with older cows. Limit water depth to 6-8 inches for fresher water and less debris accumulation.

Access to adequate fresh water becomes even more important in summer as consumption per cow increases. Consider locating extra water tanks in the barn for use during hot weather. In fact, design space for such tanks in new barns. Heaters will not be required as these tanks will be removed for cold weather.

FLOORS

Concrete floors must have adequate texture for good footing. Not only does a properly textured floor help eliminate injuries that may result from cows slipping and falling, but the improved footing has other benefits as well. Cows having sure footing are more likely to go to feed and water and to seek out free stalls for lying down. Also, heat detection will be improved.

The exact form of the textured surface for best footing has not been established. However, it appears desirable that the cow's hoof contact some part of the groove or other pattern each time it is set down. The texture very likely serves to interrupt an impending skid.

In new construction, grooves or other patterns should be cut or floated into fresh concrete. Existing floors which have been worn smooth should be grooved or otherwise roughened to reduce slipping. With saw cutting, aim for grooves cut 1/2 to 3/4 inch wide, 3/4 inch deep and 3-1/2 to 4 inches on center. An alternate treatment is done with a machine called a scabbler. A series of hammers pound the surface, providing a roughened effect. More than likely, sawed grooves are a more long-term solution than the shallower treatment of the scabbler.

SUMMARY

Design of cost efficient livestock facilities must take into account the needs of the people who will be using these facilities and their ability to implement management programs. As well, the design of these facilities must meet the needs of the animals being housed in order to maximize productivity, health and welfare. Sometimes, providing for these needs may add to the cost of the facility with no prospect of increased return. Or, provisions may be an improvement for the animal but may not cost any more than the usual way of doing things; e.g., free stall partitions that allow the cow to rise easily usually cost no more than more conventional loop-style partitions. In certain cases, making things better for the animal may, in fact, increase returns, not only through increased productivity, but decreased costs as well. For example, barns designed for full wall ventilation can be built at less cost than conventional designs. Moreover, full wall ventilation minimizes the slump in milk production typically associated with hot weather. Existing design guidelines must be continually reevaluated and updated as we learn more about the relationships between facilities and the animals that use them.

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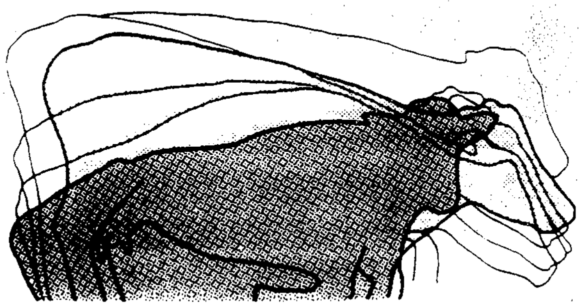

Figure 1. A cow thrusts her head forward as she lunges during rising.

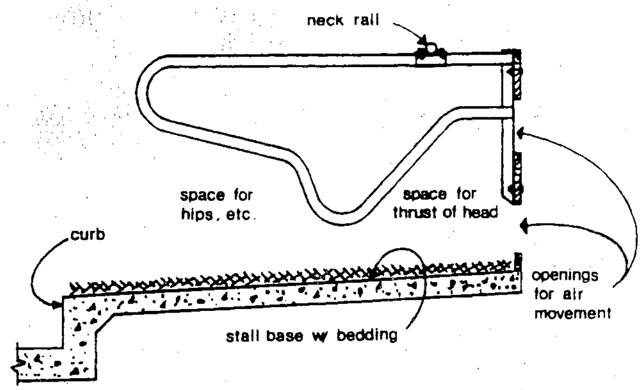

Figure 2. An improved free stall partition.

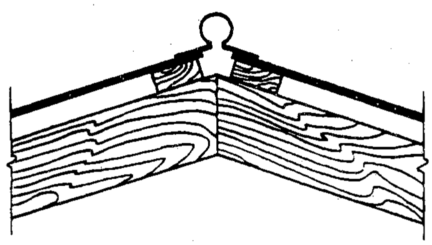

Figure 3a. A building peak with ridge cap.

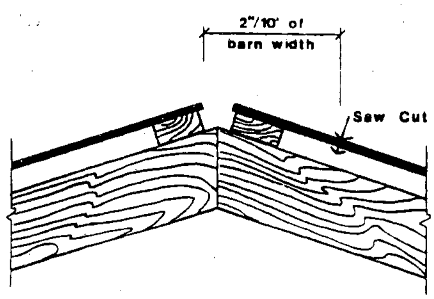

Figure 3b. The ridge is being opened by removing the cap and some roofing.

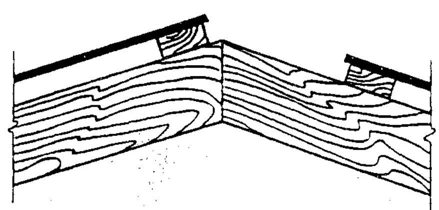

Figure 3c. The exposed purlin has been moved down under the new edge and nailed in place.

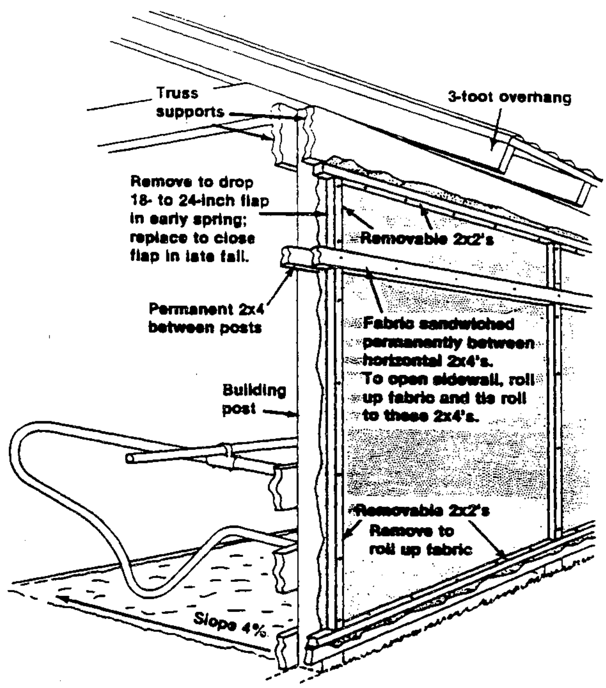

Figure 4. Full wall ventilation; open in summer, covered with fabric or other material in winter.

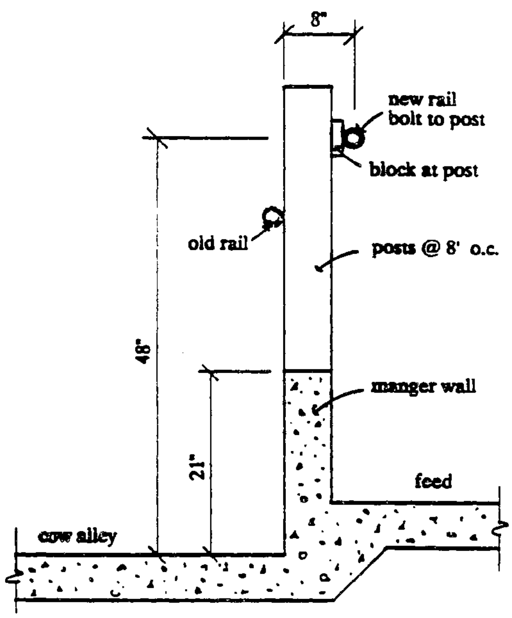

Figure 5. A post and rail feeding barrier.

OXYTOCIN UPDATE FOR PRACTICING VETERINARIANS

Jeffrey K. Reneau, DVM, MS
Extension Animal Scientist, Dairy Management
Department of Animal Science, University of Minnesota, St. Paul, MN

Oxytocin is a small octapeptide hormone released from the posterior pituitary via a neuroendocrine reflex initiated by mechanical stimulation of the teats. Oxytocin release causes marked contraction of smooth muscle: in particular the uterus and the myoepithelial cells surrounding the milk secreting alveolus of the mammary gland. Functionally, oxytocin has a role in parturition and milk ejection. Oxytocin will cause similar physiologic responses across many species.

Petersen and Ely at the University of Minnesota in 1941 were the first to demonstrate oxytocin's specific role in milk ejection. Numerous studies were conducted throughout the 1940's and early 1950's on the physiologic effects of oxytocin. Most studies did demonstrate an increase in milk production when oxytocin was administered for consecutive milkings over a short period of time (5-10 days) (10,13,14).

Donker et al. (3) demonstrated large increases in milk and butterfat production in a three lactation study of one set of identical twins. Comparisons in milk and fat production was made by injecting one cow with oxytocin (3 IU) at each milking for an entire lactation while the other cow served as control.

Injection of exogenous oxytocin may not always result in increased milk production. The injection of relatively large doses of oxytocin inhibited milk production in laboratory rats (11). Hansen and Wagner found that injecting high does of oxytocin (100-400 IU) in dairy cattle also reduced milk yield during oxytocin treatment period (7). However, this data was not sufficiently strong to be very conclusive.

Recently, Galton and Norstrand reported 10-12% increases in lactational milk production when cows were injected with 20 IU's of oxytocin just prior to each milking for an entire lactation (5). Response to the oxytocin injection was not apparent until after 60 days in milk.

The mechanism of this increased production was not explained by the Cornell research. However, there are two theories speculating the reason that continuous use of exogenous oxytocin increases milk production. The most substantiated theory is that injection of oxytocin at each milking causes greater evacuation of milk at milking time thus reducing the amount of residual milk. This would be similar to the mechanism given for increased milk yield due to 3X milking. Removal of milk both from the udder and each individual alveolar cell results in maintaining higher rates of secretory activity in alveolar cells for longer periods of time. The other theory involves a speculated indirect interaction of oxytocin on other hormones such as prolactin, somatotropin, etc. resulting in higher secretory activity of the alveolus. This proposed mechanism has no proven scientific support at this time.

Publicity of the recent Cornell findings has created considerable interest on the part of both veterinarians and farmers. Some have felt compelled to use oxytocin as a production aid. Yet, there are many unanswered questions about long term continuous use of oxytocin.

Donker et al. found that cows continuously treated with 20 IU of oxytocin at each milking, became dependent on exogenous oxytocin to achieve milk letdown (4). This dependence was transitory with normal milk letdown returning a few days after the oxytocin injections were stopped. Hansel and Wagner made a similar observation in cows being injected with large doses (100-400 IU) of oxytocin (7).

During the late 1950's and early 1960's, researchers became interested in the potential of oxytocin use in regulation of the estrous cycle. Armstrong and Hansel found that injection of 100 IU's oxytocin subcutaneously in dairy heifers early in the estrous cycle inhibited corpus luteum development and shortened the estrous cycle to an average of 11 days (1). Other studies with oxytocin doses ranging from 50-200 IU administered either IV or SubQ in both lactating cows and heifers showed similar results with estrous cycle lengths as short as 8-12 days (2,7,8,15). However, the use of oxytocin or oxytocin in combination with progesterone did not prove to be a practical method of estrous synchronization in cattle. It is interesting to note that the leuteolytic effect of oxytocin required the presents of the uterus. Hysterectomized heifers did not respond to the oxytocin treatment. One could speculate that this may implicate an oxytocin-prostaglandin link.

The oxytocin dose levels in these experiments was clearly in excess of that necessary to provoke maximum milk letdown response. Gorewitt and Sage, for example, demonstrated maximum milk letdown response was achieved at 2-3 IU oxytocin IV (6). Studies of the long termed effects at "moderate" oxytocin dosage levels (20-40 IU) on reproductive performance have not been conducted.

The Bottom Line: It's Illegal

The bottom line on this issue is that oxytocin is not labeled for continuous use as a production aid. To use it in this manner is illegal. The FDA approved labeled indicates very clearly that oxytocin is a therapeutic prescription drug. (Figure 1)

In order for oxytocin to be approved for injection at each milking as a production enhancing drug, will require extensive research similar to any other drug intended to be used in this manner.

Figure 1

Product name	Vetocin Injection	NADA 046-822
Sponsor	Forbes Labs	
Active Ingredients	Oxytocin	
Classification	Oxytocics	
Formulation	20 USP units of oxytocin/ml	
Product type	Therapeutic drug R_x **Route** Injectable - IM, IV, SQ	
Approved species	Dairy cattle, beef cattle, horses, cats, dogs, sheep, and swine	
Withdrawal time	Cattle, swine, sheep, and horses: none **Milk discard** None	
Indications	Use as a uterine contractor to precipitate and accelerate normal parturition and postpartum evacuation of uterine debris. In surgery, it may be used postoperatively following cesarean section to facilitate involution and resistance to the large inflow of blood. It will contract smooth muscle cells of the mammary gland for milk letdown if the udder is in the proper physiological state.	
Directions	When using for obstetrical purposes, administer the following doses- *Ewes: 1.5 ml to 2.5 ml *Sows: 1.5 ml to 2.5 ml *Cows: 5.0 ml When using for milk letdown, administer the following doses by IU injection-- *Sows: 0.25 ml to 1.0 ml *Cows: 0.5 ml to 1.0 ml	
Further information	do not use in cases of dystocia due to abnormal presentation of the fetus until correction is accomplished. For prepartum usage, full relaxation of the cervix should be accomplished either naturally or by administration of estrogen prior to oxytocin therapy. Treatment may be repeated as conditions require.	
References	21 CFR 522, 1680; Fed. Reg. 06/10/74 (20370)	

At present, there is no human safety data on oxytocin used as a production aid. Since oxytocin will illicit similar physiologic responses across many specifies, including man, this becomes a very important question. When cows are treated at each milking, how much oxytocin can be found in the milk? If oxytocin is in milk, how stable is it? Is oxytocin in milk broken down quickly by the enzyme oxytocinase as it is in the cows own bloodstream? Are there any side effects on the cow relative to health and productivity?

These are just a few of the kind of questions that must be answered before approved usage of oxytocin as a production aid is given.

Will Oxytocin be Approved as a Production Aid?

There are presently 10 companies that have an FDA approved oxytocin label. Only 5 are currently marketing a product. What is the likelihood that any one of these companies will attempt to do the necessary research to get FDA approval? In the author's opinion, there appears to be little economic incentive for any single company to make such an investment. Therefore, it is doubtful that there will ever be any attempt to seek FDA approval for oxytocin used as a production aid.

Conclusion:

From the limited amount of research conducted to date, it appears that injection of moderate does of oxytocin at each milking will increase milk production. However, there are many unanswered questions about the use of oxytocin in this manner. Perhaps the most important issue is the question of human safety of dairy products potentially containing oxytocin. Until more information on oxytocin is generated and FDA approval for oxytocin use as a production aid is given, it should only be prescribed and used according to its therapeutic intent.

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Adapting Bovine Behavior to Improve Performance

Temple Grandin Ph.D.
Animal Science Department
Colorado State University
Fort Collins, Colorado

Introduction

The relationship between a stockman and his cattle will affect productivity. Quiet, gentle handling will reduce stress on animals and improve production. Dairy cattle and other livestock readily adapt to many handling procedures. This paper will review how livestock adapt to handling procedures and ways to reduce handling stress.

Reducing stress is important because stresses imposed during handling can have a detrimental effect on reproduction, milk production, immune function and rumen function. Restraint, electric prods and other handling stresses lowered conception rates (Stoebel and Moberg, 1982; Hixon et al., 1981; Stott et al., 1975). Transportation and restraint stress reduced the immune function in cattle and pigs (Kelley et al., 1981; Blecha et al., 1984; Mertsching and Kelley, 1983). Rumen function was impaired by transit stress (Galyean et al., 1981). In the studies conducted by Galyean et al., (1981), Kelly et al., (1981), and Blecha et al. (1984), the stress imposed by transit had a greater detrimental effect on the animal's physiology than the stress of feed and water deprivation for the same length of time. Handling sheep with dogs and transport and sorting two to three weeks after mating caused early embryonic losses (Doney et al., 1976).

Vision and Cattle Handling

Livestock have wide angle vision. Cattle have a visual field in excess of 300 degrees (Prince, 1977). Loading ramps and handling chutes should have solid side walls to prevent animals from seeing distractions outside the chute with their wide-angle vision (Rider et al., 1974; Grandin, 1980a, 1982). Moving objects and people seen through the sides of a chute can cause balking or frighten livestock. Solid side walls are especially important if animals are not completely tame or they are unaccus- tomed to the facility. Blocking vision will stop escape attempts. Sight restriction will lower stress levels (Douglas, et al., 1984; Hale et al., 1987). The wildest cow will remain calm in a darkened artificial insemination box which completely blocks vision (Parsons and Helphinstine, 1969; Swan, 1975).

Livestock have color perception. Numerous investigators have now confirmed that cattle (Darbrowska et al., 1981; Gilbert and Arave, 1986; Thines and Soffie, 1977) possess color vision. Handling facilities should be painted one uniform color. All species of livestock are more likely to balk at a sudden change in color or texture.

Adaption to Sounds

Cattle are more sensitive than people to high frequency noises (Ames and Arehart, 1972; Kilgour, 1983). The auditory sensitivity of cattle is greatest at 8000 hz and sheep at 7000 hz (Ames, 1974). The human ear is most sensitive at 1000 to 3000 hz. Unexpected loud or novel noises can be highly stressful to livestock. Sheep exposed to exploding firecrackers or noise in a slaughter plant had increased thyroid hormone levels and elevated cortisol (Falconer and Hetzel, 1964; Pearson et al., 1977). A loud ringing bell from an outdoor telephone will raise a pasture raised calf's heart rate 50 to 70 beats per minute (T. Camp USDA Experimental Station, College Station, TX, personal communication). Animals will readily adapt to reasonable levels of continuous sound, such as white noise, instrumental music, and miscellaneous sounds. Continuous exposure to sounds over 100dB reduced daily weight gain in sheep (Ames, 1974). However, moderate, continuous background sound can actually improve weight gain in some cases. Ames, (1974) found that sheep exposed to 75 dB of miscellaneous sounds (roller coasters, trains, horns, etc.), white noise, or instrumental music gained weight faster than controls without continuous background sound.

Dairymen have learned from practical experience that continuous playing of a radio with a variety of talk and music will reduce the reaction of livestock to sudden noises. Providing controlled amounts of continuous but varying background sound may help prevent weight gain or milk production losses caused by unexpected noises.

An interview with a top Wisconsin dairyman revealed the adaptability of dairy cows to sound. On one farm a radio was never played and the cows were disturbed by every little sound. On another farm, the cows stood quietly while children played in the aisle. They had become accustomed to a variety of sounds and activity. When a jackhammer was used in their barn production was not lowered. It is highly likely that the jackhammer would have had a very bad effect on production at the first farm.

Flight Zone

An important concept of livestock handling is flight zone. The flight zone is the animal's "personal space". When a person enters the flight zone the animals will move away (Grandin, 1980a, 1987). Understanding of the flight zone can reduce stress and help prevent accidents to handlers. The size of the flight zone varies depending on the tameness or wildness of the cattle (Grandin, 1980a). The flight zone of extensively raised beef cows may be as much as 50m (164 ft) whereas the flight zone of feedlot cattle may be 2m (6 ft) to 8m (26 ft) (Grandin, 1980a). The high producing cows at the Purdue University dairy farms are very tame and have no flight zone. The size of the flight zone will slowly diminish when animals receive frequent gentle handling.

Extremely tame livestock are often difficult to drive because they no longer have a flight zone. These animals should be led with a feed bucket or halter or trained to a handling routine. A good example of training cows to a handling routine is entering and exiting from a milking parlor. The size of the enclosure the livestock are confined in may affect flight zone size. Sheep experiments indicated that animals confined in a narrow alley had a smaller flight zone compared to animals confined in a wider alley (Hutson, 1982) Approaching an animal head on will increase flight zone size (Bud Williams, personal communication).

When a person enters an animal's flight zone it will move away. If the handler penetrates the flight zone too deeply, the animal will either bolt and run away, or turn back and run past the person. When the flight zone of a group of bulls was invaded by a mechanical trolley, the bulls moved away and maintained a constant distance between themselves and the trolley (Kilgour, 1971). The best place for the person to work is on the edge of the flight zone (Grandin, 1980a). This will cause the animals to move away in an orderly manner and help reduce stress. The animals will stop moving when the handler retreats from the flight zone.

Many people make the mistake of deeply invading the flight zone when cattle are being driven down an alley or into an enclosed area such as a crowd pen. If the handler deeply penetrates the flight zone, the cattle may turn back and run over him (Grandin, 1987). This is especially a problem with cattle with a large flight zone. If the cattle attempt to turn back, the person should back up and retreat from inside the flight zone. The reason why the livestock attempt to turn back is because they are trying to escape from the person who is deep inside their flight zone. Cattle sometimes rear up and become agit person leaning over the chute and deeply penetrating the flight zone (Grandin, 1983). The animal will usually settle back down if the person backs up and retreats from the flight zone. Inexperienced handlers sometimes make the mistake of attempting to push a rearing animal back down into a chute. The animal will often react to this by becoming increasingly agitated. Both the handler and the animal have a greater likelihood of being injured.

Deep penetration into a cow's flight zone during milking may explain this odd finding. Calves reared in stalls where they are visually and tactility isolated from other calves give more milk when they mature compared to calves which are reared in stalls which provide visual and tactile contact with other calves (Warnick et al., 1977). Isolated calves which only see poeple have a much smaller flight zone than calves that have had some contact with other calves (Creel and albright, 1988). The isolated calves do not appear to be more socialized to people. In an open field test they do not have a greater tendency to approach a stationary person compared to the other calves. However, when the person moves towards them, the isolated calves are less likely to move away.

Animals that are unaccustomed to human contact have larger flight zones. Lyons and Price (1987) reported that goats raised by people had a smaller flight zone compared to goats raised by goats. Goat raised goats remained far away from a standing person and had a lower heartrate than human reared goats that remained closer. "Wild" animals are not stressed if they can maintain a large flight distance between themselves and threatening animals or people. Possibly, procedures which reduce flight zone size such as petting may be beneficial for dairy calves. Both visual and tactile isolation of calves was stressful. The isolated animals had higher cortisol levels than controls which had limited visual and tactile contact with other calves (Creel and Albright, 1988).

Herd Animals

Cattle are herd animals, and they are likely to become highly agitated and stressed when they are separated from their herd mates. Physiological changes which occur during isolation may affect productivity.

Isolation is a strong stresser. Restraint and isolation in a small box reduced immune response in pigs (Mertsching and Kelley, 1983). In sheep and cattle isolation was highly stressful (Kilgore and DeLangen 1970, Rushen, 1986, Ewbank, 1968). A dairy cow left alone in a stanchion had increased leucocytes in her milk (Lynch and Alexander, 1973).

During handling, isolated large animals that become agitated and excited are likely to injure handlers. Many serious cattle handling accidents have been caused by isolated frantic cattle (Grandin, 1987). If an isolated animal becomes agitated, other animals should be put in with it.

Cattle and sheep are motivated to maintain visual contact with each other (Ewbank, 1961; Whatley et al., 1974). Animals will readily follow the leader. Skillful handlers allow livestock to follow the leader and do not rush them. If animals bunch up, handlers should concentrate on moving the leaders instead of pushing a group of animals from the rear. Trained sheep can be used to lead sheep through a handling facility (Bremner and Kilgour, 1980) and experienced cows will lead new heifers into the milking parlor. Groups of animals that have body contact remain calmer (Ewbank, 1968). A tame pacifier cow will keep a wild cow calm during artificial insemination. The wild cow will stand quietly while maintaining tactile contact with the tame cow (Grandin, 1987).

Genetic Differences

Genetic factors affect an animal's reaction to handling. Brahman and Brahman cross cattle are more excitable and hard to handle than English breeds. Angus cattle are more excitable than Herefords, and Holsteins move more slowly than Angus or Herefords (Tulloh, 1961). When Brahman or Brahman cross cattle become excited they are more difficult to block at fences (Tulloh, 1961). Visually substantial fences built with planks or a wide belly rail should be used with these breeds (Grandin, 1987). Brahman cattle will seldom run into a fence that appears to be a solid barrier.

Effect of Environment and Experience

The previous experiences of an animal will affect how it will react to handling (Grandin, 1984a). An animal's stress reaction to a handling procedure such as transportation or restraint, depends on three important factors. These are as follows: genetics (Dantzer and Mormede, 1983; Marshall Nimis and Rempel, 1986), individual differences (Syme and Elphick, 1982/83; Ray et al., 1972), and previous experiences (Hemsworth et al., 1986; Luyerink and van Baal, 1969; Jones and Faure, 1981). Facility design can have strong influence on previous experiences. Poor design will increase stress.

Sheep raised in a barn in close contact with people had a less intense physiological response to handling than sheep raised on pasture (Reid and Mills, 1962). Cows that calved in close association with a person displayed fewer flinch, kick, and step responses during the first two weeks of milking (Hemsworth et al., 1987). Hails (1978) reported that calves lost less weight the second time they were transported. Hens which were not accustomed to being caught and handled had lowered egg production. Egg production, however, was not affected in hens accustomed to frequent handling (Hughes and Black, 1976).

Experiences at a very young age will affect an animal's reaction to handling later in life. Piglets accustomed to repeated gentle handling by people approached a strange person readily at 24 months of ageee (Hemsworth et al.,).1986. Touching a newborn foal all over will make it easier to perform a veterinary examination when it grows up because it will be desensitized to touch (Miller, 1989). Dairy calves which were removed immediately from the cow and rubbed down by a person were calmer in the milking parlor, than calves which remained with the cow for 72 hours (Albright, 1981). Maybe, the most beneficial effect could be obtained by rubbing down the calf and then putting it back in with the dam for 3 days.

Environmental Stimulation

When a barn full of veal calves or hogs hits the ceiling when a door slams, the animals may be showing signs of sensory restriction. The animals are not receiving enough stimulation for proper operation of the nervous system. Veal calves may attempt to create their own stimulation by engaging in stereotypies such as tongue rolling. Dairy cows normally receive enough stimulation during milking to prevent sensory restriction effects.

Sensory restriction sensitizes the central nervous system to external stimulation. An animal in a restricted environment becomes increasingly sensitive to stimulation in an attempt to achieve an optimal level of arousal (Walsh and Cummins, 1975).

Sensory restriction leads to electroencephalographic changes. Dogs housed singly in kennels develop abnormal electroencephalograms. The EEG's are still abnormal six months after removal from a restricted environment (Melzack, 1969). Deprivation of sensory input increases tactile sensitivity. Placement of a small cup over a person's forearm to block tactile sensations for one week, increases tactile sensitivity on the opposite unshielded forearm (Aftanas and Zubek, 1964). This effect is quite persistent. Three days after the cup is removed the other arm is still more sensitive.

Trimming the whiskers of a baby rat causes the areas of the brain that receive sensory input from the whiskers to become more excitable (Simons and Land, 1987). This effect is also persistent. The receptive fields are still enlarged three months after the whiskers regrow.

Excitability

Sensory restriction makes animals more reactive. Pairs of young dogs kept in barren kennels become more excitable and distractable (Melzack, 1969). In young animals, the detrimental effects of environmental restriction is long lasting. Ten to twelve months after release from a kennel, sensory restricted dogs are still more excitable than dogs raised with a family (Melzack, 1969). Kennel dogs confronted with a novel object such as an opened umbrella, become extremely excited. Unlike normal dogs, sensory restricted dogs do no habituate to novel stimuli

When livestock are subjected to sensory restriction, a high percentage will become more excitable, but relatively few animals will perform stereotypies.

Nervous system sensitization induced by sensory restriction, should not be confused with a generalized stress response. Sensory restriction actually lowers thresholds to incoming stimuli. Animals that live in a barren environment sometimes have increased cortisol levels, but the neural mechanisms that lower sensory thresholds probably do not operate along traditional stress pathways.

Veal calves in stalls are most likely to tongue roll when they expect to be fed. There is a large variation in calf excitability. Some producers have excitable calves and others have calm calves. Calves which jerk away as people walk by are probably understimulated. Playing a radio and some extra contact with people help. I predict that weekly grooming during the 16 week growing period would help prevent abnormal behavior. Providing extra stimulation will not hurt weight gain if it is done gently and carefully and there is a possibility it may improve performance.

Providing additional environmental stimulation will reduce excitability. Pigs raised in a windowless building with hanging rubber hose toys and weekly petting were less excitable compared to pigs raised with no extra environmental stimulation (Grandin, 1987, 1989a). Pigs raised outdoors with a variety of playthings and daily petting were more willing to approach a strange man and walk through a narrow chute compared to pigs raised indoors in small, barren pens with minimal contact with people (Grandin et al., 1987, 1989a). Loading pigs into a vehicle was more difficult when confinement reared pigs were handled. Pigs reared outdoors were easier to load (Warriss et al., 1983).

Our experiments also illustrate the different effects of environmental stimulation under different conditions. In the first trial, environmental stimulation for pigs housed in a windowless building consisted of hanging rubber hoses and weekly petting. The stimulation made the animals easier to drive through a chute and less prodding was required (Grandin et al., 1986a, 1987, 1989a). In the second trial, the animals were initially very tame and both the control and extra stimulation pens were washed twice weekly with a hose. There was a tendency for the controls to be easier to drive because the petted pigs approached people for petting. Frequent pen washing provided environmental stimulation and may have helped to calm the controls. Tame animals should be led with a feed bucket or lead rope.

Previous Handling Experiences

Animals remember painful or frightening experiences. Excitement and fear during rough handling may be more stressful to cattle than a surgical procedure. Fell et al., 1986 reported that cortisol levels after castration in calves accustomed to restraint and handling were similar to cortisol levels after transport.

Research by Hutson (1985b) and Pascoe (1986) indicated that dairy cattle and sheep could remember an aversive experience for many months. Sheep which had been inverted in a sheep handling machine were more difficult to move through the corrals the following year. Many months later, dairy cattle which had experienced electro-immobilization had elevated heart rates when they approached the place where the shock had occurred. Animals can readily discriminate and make a choice between the less aversive of two different handling treatments (Grandin et al., 1986b; Rushen, 1986). Livestock which have had previous experiences with gentle handling will be less stressed when they are handled in the future. Calves accustomed to regular gentle handling had fewer injuries during marketing because they were accustomed to handling (Wythes and Shorthose, 1984). Excitable cattle had lower weight gains (McGaugh, 1984). Dogs can be highly aversive to sheep (Kilgour and DeLangen, 1970). The use of dogs in a confined space where animals are unable to move away should be avoided. Electric prods should not be used on dairy cattle. Cattle will be easier to handle in the future if they are not allowed to rush out of corrals back to pasture. Cattle should become accustomed to walking slowly past a handler when they exit the corrals (Bud Williams, personal communication).

Cattle handled roughly in poorly designed facilities had higher heartrates compared to cattle handled calmly in well designed facilities (Stermer et al., 1981). Chickens handled gently had lower plasma corticosterone levels compared to chickens handled roughly (Broom et al., 1986). The author has observed that cattle restrained with nose tongs become more difficult to restrain in the future. Further observations indicated that when a halter is used to hold the animal's head for blood testing, restraining the head becomes easier with successive tests. Cattle blood tested with halter head restraint will learn to turn their head to expose the jugular. Cattle that have experienced nose tongs will often fling their heads about to avoid attachment of the tongs.

Animals Feel Threatened

If an animal perceives a handling procedure or contact with a person as a threat, stress may increase. Sows that withdrew from a person's hand farrowed fewer piglets than sows which readily approached a person's hand (Hemworth et al., 1981). When extra human contact is provided the handler must be careful not to intimidate the animals. He should squat down in the pen and allow the fearful animals to approach (Grandin, 1986c). He must never chase them. In our experiments, weight gains were not adversely affected by petting pigs in the pens or a weekly walk in the aisles. However, if the pigs feel threatened or are hurt, weight gains will be reduced. Gonyou et al. (1986) found that a looming, threatening person approaching the animals reduced gains. Animals can readily adapt to handling, such as daily weighing with no effect on weight gains (Peischel et al., 1980). Animals can adapt to psychological stress, but it is more difficult for them to adapt to procedures or events which are physically stressful. Salivary cortisol levels were lower in a smooth riding truck (Fell and Shutt, 1986). Stress responses to handling do not have a uniform effect across all stress measures. Cattle that are transported repeatedly will lose less weight as they become accustomed to transport. They will also adapt behaviorally. Cattle that have experienced several trips are easier to load and more sure footed in the truck (Fell and Shutt, 1986). However, their salivary cortisol levels did not decrease with successive trips. A possible explanation for this finding is that cattle would become less fearful with successive trips, but a bumpy road causes fatigue.

Pumprey (1986) reported that calves accustomed to daily handling by people on horses had no difference in weight gain compared to unhandled controls during cool weather. During warm weather, heat stress which occurred due to physical exertion lowered weight gains. Apparently, the animals knew the routine and did not feel threatened.

If a person shocked pigs every few days a chronic stress state was created (Gonyou et al., 1986). Inconsistent handling will cause stress. If a handler occasionally mistreats an animal, the animal is liable to be stressed every time the person approaches. An occasional aversive treatment lowered weight gain and increased corticosteroid levels even though the handler was gentle with the pigs most of the time (Hemsworth et al., 1987). The pigs had learned the handler could not be trusted.

Novelty can be a strong stresser. Animals that have been raised in a variable environment are less likely to be stressed when confronted with novelty. In one study veal calves were raised in indoor stalls or in outdoor group pens (R. Dantzer, personal communication, 1983). When the calves reached market weight, both groups were exposed to a new indoor and outdoor environment. Calves raised indoors had higher serum glucocorticoid values when they were put in an outdoor arena. Calves raised outdoors were more highly stressed when they were put in an indoor arena. Both of the new locations were stressful to all calves, but their reactions were influenced to the greatest extent by variance from the type of environment in which they had been reared.

Animals can be trained to accept irregularity in management (Reid and Mills, 1962). Some slight deliberate variation in routine will help prevent animals from being stressed by novelty. Ranchers have found that changing vehicles and people feeding and tending cows will help get the cows accustomed to novelty. Pigs exposed to a variety of objects approached a novel object more quickly than animals raised in a barren environment (Grandin, 1989a). However, pigs which had grown accustomed to a precise routine for bloodpressure testing, responded to a change in routine with increased bloodpressure (Miller and Twohill, 1983). Dairy cows that normally enter a parlor easily may balk and be spooked by a novel object such as a coat hanging on a fence. It is the novelty that scares the cows. If the cows saw the coat every day it would not bother them.

In our previously described handling experiment (Grandin, 1989a), the pigs initially became highly agitated during the novel experience of pen washing. When they become accustomed to pen washing they walked up to be sprayed. The experience of pen washing was initially stressful but it soon became a pleasant experience that the animals actively sought. A young hiefer's reaction to a milking parlor would be similar. When she is first confronted with the hissing, clanking equipment she is terrified, but soon she associates the parlor with the relief of getting milked. Mature dairy cows may act like new heifers if they moved to a different type of milking setup. A herd of stanchion housed Wisconsin dairy cows went absolutely beserk when they were moved onto a Florida farm with a milking parlor. The stress on these animals could have been reduced by having some experienced "parlor" cows to help lead them in.

New Restraint Concept

The idea of training an animal to voluntarily accept restraint is a new concept to some people. Animals that are handled gently can be trained to voluntarily accept restraint in a comfortable device (Grandin, 1986a, 1989b, Panepinto et al., 1983). Stress on both animals and people will be reduced. Large animals that are trained to walk into a restraint device for veterinary treatment can easily be handled by one person. Cooperative large animals are less likely to injure people or themselves. Feed rewards can be used to facilitate animal movement through a handling facility (Hutson, 1985b). Many dairymen do not realize that every time a cow walks into a milking parlor she is voluntarily accepting restraint.

The author has trained sheep to voluntarily enter a squeeze tilt table for a grain reward (Grandin, 1989b). Some sheep were squeezed and tilted to a horizontal position nine times in one day. After being released from the squeeze tilt table, the animals rapidly ran into the crowd pen and lined up in the chute (Grandin, 1989b).

To train the animals to voluntarily accept restraint, the restraint device must be introduced gradually and gently with feed rewards (Grandin, 1989b). At first, the animal is allowed to walk through the restrainer several times. The next step is to allow the animal to stand in the restrainer without being squeezed. On the fourth to fifth pass through, the squeeze is applied gently. During each step the animal is given a food reward of palatable feed. A relatively tame animal can be trained to voluntarily enter a restrainer in less than an hour.

Training animals to voluntarily enter a restraint device is easier and less stressful if the animal is tame and has little or no flight zone. If a wild animal is being trained, it is important to catch it correctly on the first attempt. Fumbling and failing to restrain an animal on the first attempt will result in increased excitement (Ewbank, 1968). If an animal resists and struggles, it must not be released until it stops struggling, otherwise it will be rewarded for resisting (Grandin, 1986a). Animals that are released while resisting are more likely to resist in the future (Grandin, 1986a). The animal should be stroked and talked to gently until it calms down. Animals will not voluntarily accept restraint if the restraint device causes pain. Selection of the right type of squeeze chute and headgate to fit the specific handling requirements is important (Grandin, 1980b).

Conclusions

Gentle handling improves the bottom line. Dairy cows that are not fearful of people and have no flight zone will be more productive. Jack Albright, a renowned scientist of dairy cow behavior, reported that one of the top producing dairy cows in the world had no tendency to avoid people. Cattle can become accustomed to varying amounts of stimulation and novelty. Aclimatizing cows to variation may help prevent production losses caused by unexpected novelty such as changes in personnel, a power failure, or unseasonal severe thunderstorms.

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A METHOD OF TREATING AND WRAPPING THE COW'S HOCK EXHIBITING CELLULITIS, HEMATOMAS, ABSCESSES AND/OR DRAINING TRACTS

John F. Anderson, DVM, MS
Professor
Department of Large Animal Clinical Sciences
University of Minnesota

The swollen hock of the dairy cow is a difficult clinical problem to handle. The first assessment to make is the cow's rectal temperature. The cow's temperature is often slightly to markedly elevated depending on duration and severity of the lesion.

Digital palpation is next applied to ascertain granulation, fluctuance or localized inflammation. If the swelling is "hot," the leg is wrapped and systemic antibiotics are given. If the swelling is fluctuant and "cold," the hock is prepared with three Betadine® surgical scrubs. This is followed by swabbing with strong tincture of iodine. The iodine is subsequently removed with 70% alcohol. A sterile, 16 gauge, 1½" needle attached to a 12 cc syringe is then inserted at the ventral most aspect and aspiration reveals the content. If the aspirate is bloody (hematoma) the hock is simply wrapped as later described. If the aspirate is clear and appears to be free of joint fluid or indicates abscess material, the swelling is opened with a #10 Bard-Parker blade. This opening is established at 2 sites; one dorsally and one ventrally and each incision is made in a cruciate pattern. After the incisions are completed and the lesion is flushed with peroxide and strong tincture of iodine, a double piece of 3" gauze which has been soaked in iodine should be drawn through both incisions and tied with a square knot on the outside to maintain a semipermanent drain. Nolvasan® (Fort Dodge laboratories) teat dip concentrate is applied to the amount of cotton which is required to completely circumvent the hock. Application of Nolvasan® to cotton is accomplished by cupping the hand beneath the cotton and pouring a small amount of Nolvasan® teat dip concentrate into the depression in the cotton. The hock is then wrapped with Nolvasan® teat dip concentrate applied immediately over the affected hock area. A roll of three inch gauze is then applied with only enough tension to hold the cotton on the leg.

The wrap is completed with 2 rolls of 3" Elasticon® (Johnson & Johnson). For application of Elasticon® on the upper leg, the udder must be pushed aside. This is best accomplished by placing the hand between the udder and the leg and then pulling the roll of Elasticon® through to facilitate the most dorsal application possible. Always cover the end of the roll of Elasticon® when starting the taping procedure with the next revolution around the leg because exposed flaps are conducive to "wraps that fail." Always "close the hock" when wrapping cow's legs.

Owners are advised to observe the lower leg for swelling. If swelling is observed, the owner is instructed to partially cut the upper leg wrap and apply another roll of Elasticon® tape which is dispensed for that purpose. When hock swelling subsides, the wrap usually slips down. If the wrap has remained clean on the inside, it can be cut on the anterior aspect, pulled up, and after cleaning, cotton with Nolvasan® teat dip concentrate applied can be reinserted. The leg is then rewrapped with 1 roll of Elasticon®. If the wrap, however, is badly contaminated, it is best removed and rewrapped as indicated.

The use of Nolvasan® teat dip concentrate topically on lesions prevents absorption of antibiotics with subsequent residue problems. DMSO is seldom used, if it is applied, be sure to discard milk and observe milk and tissue residue conditions.

A wide variety of hock lesions have been handled successfully in this practice with this technique of wrapping.

HOOF TRIMMING MADE EASY

John F. Anderson, DVM, MS

Professor

Department of Large Animal Clinical Sciences

University of Minnesota

One segment of herd health that is being almost totally ignored is hoof trimming. An individual or two should be professionally trained to trim feet and be part of a dairy practice group. Hoof trimming, as it is presently performed, can be markedly improved because this procedure often predisposes animals to lameness when it is not properly performed.

A variety of stocks, tables, and chutes have been designed and built to restrain cattle for hoof trimming procedures. The instruments used for the actual trimming process, however, have not been changed basically since hoof trimming began. Instruments in the form of hoof knives, picks, chisels, nippers, and long-handled clippers, all require good physical strength and stamina on the part of the user. High speed sanders have been used for some time to smooth irregularities and shape sharp corners; however, these devices, if used with any force or for any duration, have often created laminitis with resulting acute lameness. Many of these cases of laminitis often end up as culled animals.

More recently, a much needed device in the form of a round wheel with a series of slot openings in the wheel face was introduced. This device is attached to a 4½" highspeed grinder. This unit has been used extensively for over 2 years on all types, shapes, and consistencies of hoofs. It is apparent that this new unit is to the veterinarian, dairy producer, or farrier, what the air drill is to the dentist. If this unit is maintained in a clean, sharp condition, there is absolutely no heating of the hoof surfaces contacted and therefore no induced laminitis. The hoof is trimmed rapidly with a minimum of effort and therefore it is less traumatic to the animal. Good restraint is a necessity, especially for the novice operating this highspeed device. In order to familiarize oneself with this trimmer, a piece of pine wood should be secured in a bench vice as a good experimental beginning to get the feel of this trimmer.

In teaching senior veterinary students how to operate this unit, it has been helpful to begin by trimming the excessive length of the cow's hoof with a long-handled hoof trimmer. This provides a "benchmark" to gauge depth and angle of cut. The sole of the hoof is then removed with the electric trimmer, primarily over the toe, so that the squared off cut, left by the long-handled clipper, is removed. This rotates the tip of the hoof down when the cow is placed in the standing position after trimming is completed. The foot of the cow will then assume a normal conformation (approximately 45° angle) with respect to the flat surface on which the cow is standing. Unless the heel of the foot is cracked and needs medical attention, only minimal trimming is performed over this structure.

A mistake seen commonly in hoof trimming is to trim so that the entire sole of the hoof is flat on the floor when the cow assumes a normal standing position. When cows' hoofs are properly trimmed, the sole of the entire hoof should be concaved. When this is accomplished, a large percentage of the cows' weight will be born on the walls of the hoof (at the outer edge). When walking, the cow will wear down the hoof wall and hoof trimming is required only once or twice yearly as opposed to three times yearly if the sole is left flat. Concaving the bottom of the foot reduces sole bruises which often occur when the sole of the foot is improperly trimmed.

Trimming should cease with this or any device when the sole of the foot "gives" under thumb pressure.

This wheel is an excellent method to remove excessive hoof in a diagnostic hoof trim. Abscess tracts are more easily found, investigated, drained and treated. In addition, this often unpleasant task is made easier. The cow is under stress for a shorter period of time and the outcome of the case is improved.

Wrapping the treated foot is best accomplished by the application of strong tincture of iodine or Betadine® solution on cotton. The cotton with iodine or Betadine® is then applied to the affected area. Three inch roller gauze is used to secure the cotton to the foot followed by one roll of Vetrap® (3M). When Vetrap® is used, the bottom of the foot is completely closed to reduce contamination for at least 3 to 4 days. The client should be instructed to keep the cow in an environment which is as dry as possible to encourage healing. When the bottom of the foot has worn through the Vetrap® bandage, the owner should be instructed that the remainder of the bandage circumventing the hoof, should be removed. Healing is usually complete if the case is not complicated in a short period of time.

ProStaph I^{TM} 1990

Kevin F. Nigon, D.V.M.
Northern Valley Animal Clinic
Rochester, Minnesota 55904

Mastitis continues to be one of the leading economic losses for the dairy industry in the 1990's. The National Mastitis Council estimates that losses caused by mastitis amount to approximately $180 per year for each and every cow in the milking herd. Approximately 70% of this loss is due to lost milk production from subclinically infected cows.

Staph aureus is a major cause of contagious mastitis in dairy cows. S. aureus usually establishes itself on the teat end before gaining access to the gland portion of the udder via the teat duct. S. aureus is spread from cow to cow mainly during the milking process. The main resevoirs are infected udders and teat lesions and transmission occurs between cows via the milking unit and operators hands and common washcloths. Once established in a cow's udder, S. aureus may cause a clinical mastitis or become a subclinical infection which may eventually become a chronic infection. S. aureus produce toxins that lead to damage of cell membranes and glandular blood vessels. Destroyed glandular cells along with leukocytes may clog milk ducts and contribute to scar and abscess formation where S. aureus bacteria can hide from antibiotic treatment and break out of these formations at a later date to produce a clinical mastitis. Abscess and scar tissue formation make S. aureus infections very difficult to eliminate and also contribute to the spread of S. aureus from cow to cow.

Identifying S. aureus infected cows becomes very important in attempting to control and eradicate the disease because of the properties of S. aureus mentioned previously. Once cows are identified as S. aureus carriers, they can be culled or segregated from uninfected cows in the dairy herd.

The usual way of identifying S. aureus infections is by individual quarter milk cultures. Culturing individual cows is a difficult and time consuming job and may yield inconsistent results due to the intermittent shedding pattern of *S. aureus* or the shedding of low numbers of bacteria undetectable by usual culture techniques.

A new method of detecting *S. aureus* infected cows, ProStaph I™, has recently been introducted by ProScience Corporation. ProStaph I is a test kit used to detect *S. aureus* antibodies in cow's milk. The one hour ELISA test can be conducted on preserved or raw milk and does not require aseptic collection. According to ProScience Corporation, culture and SCC results may be variable and/or misleading in *S. aureus* infected cows due to the intermittent shedding pattern of the bacteria. Antibody levels however tend to remain elevated in persistently infected cows even during periods when they do not shed enough *S. aureus* for culture detection.

ProStaph I is available commercially through DHIA milk testing programs, other milk quality laboratories, and veterinarians. ProStaph has been used to identify *S. aureus* infected cows through several DHIA centers including Washington and Wisconsin.

Minnesota DHIA started a pilot program to evaluate ProStaph I on selected Southeastern Minnesota dairy herds in the late fall of 1989. The study is under the direction of University of Minnesota extension personnel and involved local veterinarians who identified *S. aureus* infected herds and supplied the initial contact between these herds and University personnel. A total of 10-12 *S. aureus* infected herds were required to gather the initial information on ProStaph I.

The goal of the program was to develop guidelines on the use of ProStaph I as a culling and segregation guide in *S. aureus* infected herds. By culling and segregating infected cows, the ultimate goal was to prevent the spread of *S. aureus* and to eventually eradicate the bacteria from the herd. For the purpose of this project, once a cow is identified as *S. aureus* positive, she is considered always S. aureus positive and is either culled or segregated from uninfected cows during milking time.

All herds enrolled in the project had their milking equipment evaluated to ensure that it was operating properly. Milking techniques were evaluated by trained personnel and all dairymen were required to follow good, well accepted milking procedures.

After the initial screening process was completed, all milking cows in the project dairy herds were tested twice at two successive DHI test days using the ProStaph. All tests were run at the Zumbrota DHI laboratory using the normal DHI test day sample. After the first test, cows were classified as either negative, suspect, or positive to S. aureus antibody based on ProStaph results. Suspect cows are cows which are in the first thirty days of lactation or have production levels less than thirty pounds of milk and test positive on ProStaph. These cows may have positive antibody results due to the transportation of antibodies from the blood into the milk as a result of colostrum production and not an actual S. aureus infection. These positive results are listed as suspect and retested.

A milking order was established after the first test with negative cows milked first, suspect cows second, and positive cows last. These results were checked on all cows at the second DHI test and the milking order was evaluated based on these results. All cows must have two consecutive tests either negative or positive before being permanently placed in their respective milking order. After the first two tests, all fresh cows, and new cows entering herd were tested at two consecutive DHI tests and all suspect cows were retested until two negative or positive results were achieved. All new cows and fresh cows are milked as part of the suspect group until ProStaph tested.

After the initial two tests were completed, the ability of each dairyman to prevent the spread of S. aureus was evaluated by testing the bulk tank milk from negative cows only (2 samples from bulk tank were collected) by both culture and ProStaph. If the bulk tank sample tests positive for S. aureus and no reason can be found and the result is confirmed by a retest, then all negative cows must be individually retested using ProStaph.

The study is continuing at this time and all results are preliminary. Results are encouraging to this point. Most dairymen appear to be able to maintain their negative cow status. A few positive results have occurred, but some may be due to including untested fresh cows and/or suspect negative cows tested once in the negative bulk tank sample. More bulk tank results are necessary to clarify these findings.

Other interesting findings include ProStaph positive fresh primiparous cows and ProStaph positive cows with low SCC linear scores.

The pilot project is planned to run for 12-15 months to gather information and to work out sample handling and reporting procedures by DHI personnel. As the study continues and more data is collected, the use of ProStaph I should become more well-defined and ProStaph I may become a valuable tool in battling S. aureus mastitis in our Minnesota dairy herds.

RECTAL PALPATION: SAFETY ISSUES

Harry Momont, DVM, PhD
Diplomate, American College of Theriogenologists
University of Minnesota
College of Veterinary Medicine

Rectal examination, or palpation, of the reproductive tract is the standard method of bovine pregnancy diagnosis and has been for the last 50 years. It has been routinely employed in veterinary practice for more than 90 years (1) and there are numerous references to transrectal pregnancy diagnosis in the veterinary literature dating back to the early 1800's. The veterinary profession's early reluctance to adopt the technique was attributed to its potential to produce abortion, but was more likely due to aesthetic objections that were especially meaningful in the era before rubber sleeves and gloves. With adequate training, sensory desensitization, and the use of disposable plastic sleeves, most veterinarians today view rectal palpation as a routine procedure. (Author's note: Although we do not technically palpate the rectum, but rather the reproductive tract through the rectal wall, I nevertheless prefer "rectal palpation" to the possibly more correct but certainly more cumbersome "manual palpation per rectum.")

Change in uterine size and location, the detection of fluid in the uterine lumen, middle uterine artery hypertrophy and fremitus, and the presence of a mature corpus luteum on the ovary are signs consistent with pregnancy and detectable by rectal examination of the cow sometime after 30 to 35 days of gestation. Certain pathological conditions, most notably pyometra, can produce these signs as well. For a positive diagnosis of pregnancy in the cow, one of the four positive signs of pregnancy should be detected (2). These are: 1) palpation of the chorioallantois using the fetal membrane "slip" method (FMS); 2) detection of the amniotic vesicle (AV); 3) palpation of placentomas; and 4) palpation of the fetus itself.

Rectal palpation is considered by most to be a safe, accurate method for pregnancy diagnosis in cows from about day 30 to 35 of pregnancy until term. Diagnosis is possible a few days earlier in heifers. A diagnosis of nonpregnant should never be made until the uterus has been retracted and carefully palpated along its entire length.

Differential diagnoses that should be considered for pregnancy in the cow include pyometra, fetal mummification, fetal death and/or maceration, segmental aplasia with accumulation of fluid, adhesions of the reproductive tract to other abdominal organs, uterine lymphoma, abscesses of the reproductive tract, and ovarian tumors. Mistakes involving these conditions should not be made if the examiner relies on the positive signs of pregnancy mentioned above.

Concerns about rectal palpation have always existed but have not been judged significant enough to override the advantages of this technique for pregnancy diagnosis in the cow. The concerns have taken two principal forms, those of accuracy and those of safety. I feel that after 35 days of gestation, the accuracy of the technique of rectal examination for pregnancy diagnosis is virtually absolute, however, it is important to remember that this does not necessarily apply to every practitioner of the technique. Errors can occur as the result of inadequate training or skill, or a hurried examination. Cows that are obese or those that have experienced significant rectal trauma from previous examinations may require alternative methods for pregnancy diagnosis. It is important to remember that failure to produce a calf after a positive pregnancy diagnosis does not necessarily mean the diagnosis was in error. The possibility of undetected fetal loss following but unrelated to the examination must always be considered when cows diagnosed pregnant are subsequently found to be nonpregnant.

Concerns about safety of the technique for the fetus itself, though possibly overstated, are not so readily dismissed. It is worth noting that a number of veterinary teaching programs, where relatively inexperienced students palpate client animals, have reported no obvious problems with fetal loss (3,4,5). However, there are at least 2 reports of increased fetal loss after rectal examination for diagnosis of pregnancy. Abbit et al. (6) reported that palpation of either the AV or the FMS resulted in increased fetal loss when compared to diagnosis of pregnancy by the presence of fluid alone. Palpation of the FMS was deemed more dangerous than palpation of the AV. While the authors' recommendation that palpation of fluctuation be used as a sole diagnostic method precludes obtaining one of the 4 positive signs of pregnancy, they concluded that the presence of fluid by itself was sufficient for diagnosis of pregnancy.

More recently, Franco et al. (7) reported that palpation of fluctuation, FMS, and the AV together caused fetal death in about 10% of cows palpated between 42 and 46 days of gestation. Progesterone monitoring of a contemporary group of bred cows that were not palpated until 90 days of gestation served as controls. This is an unacceptably high rate of induced loss and the authors recommended either waiting until 46 days after breeding to palpate cows for pregnancy diagnosis or, based on the report of Abbit et al. (6), to use the finding of fluid or fluctuation of the uterine horn as a sole criterion for pregnancy diagnosis. Certainly it is undesirable to wait more than two cycles after breeding before diagnosis of pregnancy is made, so palpation of fluid may be the more realistic recommendation. It is perhaps significant that the definitive determination of pregnancy status in this experiment was by rectal palpation, albeit at 90 days.

Although Abbit et al. (6) reported AV palpation to be safer than FMS, it has long been the convention to recommend against AV palpation, especially for relatively inexperienced palpators. Manual crushing of the AV is a well established cause of fetal loss. A further cause for concern regarding AV palpation was raised by Bellows et al. (8) when they suggested that diagnosis of pregnancy by palpation of the AV between 35 and 44 days of gestation was a possible cause of colonic atresia or stenosis in calves. This suspicion seems to have been confirmed by a clinical investigation in Germany (9) where a single practitioner was apparently responsible for an epidemic of atresia ani in calves. The problem began after changing the timing of pregnancy diagnosis by the AV method from 45 days after breeding to 35 days. My recommendation at this time is to avoid palpation of the AV altogether before 45 days of gestation and to use it only when required for evaluation of possible problem or twin pregnancies.

While I feel that palpation by a skilled clinician using the FMS method after 35 days of gestation is presently the most practical method of bovine pregnancy diagnosis, I am open to suggestions that it may not be entirely safe. Final resolution of the palpation safety question awaits a pregnancy diagnostic technique that is demonstrably superior in terms of accuracy and safety. I do not believe that any of the methods that have been used to date meet these criteria. Of the new techniques, real-time ultrasound is the one most likely to provide the answer to the question of palpation safety.

Finally, a concern has arisen about rectal palpation that is not specifically related to the issue of pregnancy diagnosis. Most clinicians are aware that hemorrhage of the rectal mucosa can occur during palpation. It is likely that most cows experience some degree of hemorrhage during rectal examination, although it is usually not grossly detectable. Bacteremia can also occur after rectal palpation, but is probably not a clinically significant problem (10). These observations generate concern that the use of a common examination sleeve for rectal palpation of more than one cow may result in transmission of disease from one animal to another.

Intra-rectal inoculation of whole blood (11) and simulated rectal palpation using a sleeve inoculated with whole blood (12) have resulted in transmission of bovine leukemia virus (BLV) from viremic to seronegative cattle. However, an epidemiologic study of over 2,000 cows failed to find an association between the prevalence of infected and noninfected cows palpated at one time with a common sleeve, and subsequent seroconversion of cows to BLV (13). This issue, and the possibility that other diseases (eg, anaplasmosis or paratuberculosis) may be transmitted in a similar fashion are certainly a concern for veterinarians who offer reproductive herd health programs. It may be wise to institute a practice of using individual sleeves for rectal examination, especially in herds that are involved in BLV or Johne's eradication programs.

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MANAGEMENT TECHNIQUES TO IMPROVE MILK QUALITY

David A. Reid, D.V.M.
Rocky Ridge Veterinary Service, S.C.
Hazel Green, Wisconsin 53811

MILK RESIDUES

The past calendar year has really been exciting for those of us involved in the dairy industry. Prices have continued to increase and at January 1st stood at record levels. With the exception of butter, minimal or no dairy products have been purchased by the Federal government. I cannot personally remember a time when there has been such a positive outlook on the future of the dairy industry in the United States. However, I think that there is a major problem that lies just beneath the current rosy surface of our industry. The antibiotic residue problem is a very real threat to the dairy industry. The dairy industry's ability to market a wholesome, uncontaminated product that is viewed as such by a majority of the consumers in the United States is in serious jeopardy. I am sure that most of us here today can remember the problems that occurred several years ago with contaminated Tylenol products that reached various market areas in the United States. What would happen to our industry if all milk or milk containing foods were recalled from stores and consumers shelves? The makers of Tylenol spent over 600 million dollars to gain back just some the market share that they enjoyed before the poisoning scare. With the revelations that approximately 70% of the milk samples in several metropolitan areas including Boston and Seattle were contaminated with Sulfamethazine, I feel that we in the dairy industry could also be faced with much more adverse publicity than we have seen in the recent past. There has been at least one segment of 60 Minutes dealing with the potential contamination of milk products along with articles in many national newspapers and news magazines. This publicity is definitely not what the dairy industry needs today. Currently, what publicity has been generated has not shaken the confidence that American consumers have in dairy products as a source of wholesome, uncontaminated, nutritional components of our diet. However, those of us that are involved in the dairy industry need to realize the potential devastation that could concur to our complete marketing system if adulterated, contaminated milk is not removed from the market place.

Residue Testing Milk

For many years the dairy industry has operated on the principle that we can be saved by dilution. We have taken some milk that might have low levels of contamination, we dilute it with vast amounts of uncontaminated milk and we end up with no detectable residues in our milk products. The introduction with what is commonly referred to as the Charm II test certainly has changed this. The Charm II test and several recently introduced FDA tests are many times more sensitive than any of the current methods of detecting antibiotic or sulfa residues in milk employed by the majority of our milk plants. The publicity that has been generated with the Charm II will necessitate more milk cooperatives and milk marketing plants to use this advanced technology to detect antibiotic and sulfa residues in farm bulk tank milk. In order for the dairy industry to survive, it is imperative that we understand how some of these residues can be avoided in our milk at the farm level. Unfortunately, at this point in time, there are not enough inexpensive farm tests that we can use to detect the extremely low levels of residues that the Charm II and other sophisticated tests are capable of detecting. This creates a real problem because we may feel that there is no contamination on a particular farm. In fact, there may be a contaminated feed source, an inadvertent use of an antibiotic, or an unobserved withdrawal time for certain drugs on the farm. However, these farms do not have residues that are red flagged with the conventional tests that are now being utilized at many milk plants. Therefore, this milk is mixed into the processing channels and it may not be until the product is actually on the shelf in the consumer form before the contamination is found. At that point, it is too late because the damage has been done with the product already in the market place. Here lies the problem as I see it for the dairy industry.

<u>What Must We Do?</u>

We certainly could complain about the adoption of these new sensitive tests by those in the industry who can afford the technology. However, before we make our complaints very loud and vocal, I think there are many things that we as dairy producers, dairy professionals, and especially dairy veterinarians can do to help insure that we are not contributing to antibiotic contamination of milk because of sloppy, on farm, medication procedures.

There is a fundamental change in the attitudes of both dairy producers and dairy veterinarians that I see as necessary to help resolve the potential nightmarish problems that we face with antibiotic residues. It is simple and easy to understand the change that we need. We need to change our attitude when it comes to disease problems in cows. Diseases need to be prevented and not treated. As a practicing veterinarian, I certainly have treated more than my fair share of "broken" cows. A large part of my practice today is devoted to what I call Quality Milk Production Management and Consultation. Basically, I go to farms and analyze milking equipment, milking procedures and other aspects of dairy management that contribute to quality milk production. It is astounding to me to see some of the drug products and the conditions under which drugs are stored on many of our producing dairy farms. If many of these farms were depicted in national publications or TV broadcasts, the bottom would fall out of our market. All of us sitting here today have seen this type of dairy in operation. What is really amazing to me is to look back in the literature and see that 25 or 30 years ago, approximately 50% of the cows in the United States were infected with mastitis causing organisms in one or more quarters. Over the last 25 or 30 years, the veterinary profession and dairy producers have thrown all possible antibiotic combinations either into cow's quarters, into their veins or have developed some other method of treating cows with antibiotic product. However, the level of mastitis basically is the same today as it was 25 or 30 years ago. There is a very conservative estimate on the part of NMC indicating that the average dairy cow in the United States is loosing $181 per year because of mastitis. The technology, the research, and the data are at hand to help control mastitis. However, the adoption of this information has been very slow to trickle down and become a part of everyday management on most dairy farms. Many veterinarians and dairymen find it much easier to throw antibiotics at the problem than to really look at the causes of mastitis and make the management changes to reduce the level of mastitis that we see on our farms.

Field Observations

It is truly unbelievable to see some of the drugs and products that are available on many dairy farms in the upper Midwest. I am sure that if we were to visit every dairy in the country, we certainly could find some serious problems with medications on many of the farms along with conditions under which antibiotics and treatment products are stored. I will admit that the few approved drugs for use in lactating animals, in many cases, are certainly not the most effective antibiotics to use in treating mastitis problems. My point is not to discourage or condemn the extra label use of antibiotics, but to use extra label antibiotics in a reasonable and well thought out treatment program that hopefully will insure that contaminated milk is not mixed into the normal processing channels. My advice to dairymen is to work closely with your veterinarians and to observe the withdrawal times that they recommend. All of us know that, in many cases, veterinarians go to the farm and use drugs in an extra label manner and leave written directions to hold the milk for "x" number of milkings. If you as a dairyman, in fact, send that milk to your milk processing plant and request an antibiotic test on it, you find that in many cases within a matter of two days, the milk test will be negative for antibiotics even though the withdrawal time may have been as long as 12 days. What do we do? We sell the milk. This is certainly a problem that we face today. The test that we have available at the local level, many times, will not have the sensitivity of some of the newer tests about which we are speaking. Without adequate cow side or milk plant testing of the same sensitivity, we really have a problem in maintaining an uncontaminated milk product for the consumer. There certainly is no way that the use of antibiotics can be eliminated from the average dairy farm in this country. However, drugs could and should be used in a wise and well though out manner. Drugs should not be used without a label that tells both the milk withdrawal and the meat withdrawal times that must be observed prior to marketing these products. If your veterinarian mixes a specific prescription type item for use in a certain individual cow on your farm, be sure to find our exactly what is the necessary withholding time. In many cases, the veterinarian may not have a totally accurate answer and the time interval that he recommends may, in fact, be more than is necessary. But it needs to be observed. Do not cut corners in sending the product to market prior to the recommended holding times.

As a practicing veterinarian I have many concerns about the availability of approved drugs with which to treat lactating animals. It is my opinion that we need to have milk and tissue residue withdrawal times established for products even if they are not approved in lactating animals. It is common knowledge that many products are being used in food producing animals to treat specific illnesses, but we do not have good clinical data to give us accurate withdrawal times. Many times veterinarians are faced with the task of coming up with a withdrawal time when there is no adequate data available. Most veterinarians tend to adopt recommended withdrawal times for which there is some evidence to suggest what is correct. Withdrawal time determination is a problem that veterinarians face after having had considerable training in the use of drugs and the preparation of drugs for use in animals. What about the mixtures that I see put together on the desk in the barn office? There may be as many as four or five active ingredients including a corticosteroid and possibly some other products that would help the diffusion of the drug through mammary tissue. What kind of withdrawal time would we put on this type of a product? To me, the obvious answer is that we should not use this product. We should limit the use of intramammary drugs to the minimal amount of extra label use with which we can get by. Dairymen would be well advised to use commercially prepared mastitis tube treatments and not to rely on either homemade products or even products that are routinely manufactured or put together for that use by practicing veterinarians. The potential problems with the contamination of these products with yeast and fungi and then the concurrent contamination of mammary tissue with these organisms warrants great concern. But of even greater concern, is how do we arrive at effective withdrawal times for what I call "bathtub" mixtures? I do not feel that there is any way to come up with an adequate withdrawal time for this type of product.

The Bottom Line

The production of quality, uncontaminated milk demands that:

1. Drugs be used only when necessary.
2. The treatments used have a prescribed withdrawal time.
3. These treatment products are stored on the farm in a manner such that they cannot contaminate the milk supply.

The ultimate responsibility for uncontaminated milk leaving the farm lies with the dairy producer and his veterinarian. I realize that the technology in some areas is way ahead of the technology that is available on the farm. However, rational, well thought out drug treatment programs can reduce dramatically the amount of adulterated milk that enters the market place. I firmly believe that producing uncontaminated milk remains the most important issue facing the dairy industry today.

I would like to close with a quotation from a talk presented by John Adams at the National Mastitis Council summer meeting in Tampa, Florida. "We cannot fail in this challenge for the failure will be reflected in adverse consumer and government reaction. Our failure will lead to the loss of needed drug products and the loss of consumer confidence in our product. Let us all continue to work together so that we are able to continually reassure consumers that our milk supply is the safest it can possibly be! Our number one business as cooperatives is marketing milk for the highest return for the dairy farmer members. We cannot market contaminated products."

<u>DOCKING TAILS</u>

Many dairymen in the Upper Midwest are beginning to dock tails on their cows. I think the technique was first developed mainly for freestall barns, but I know of many tie stall and stanchion barns that have adopted the practice in the last couple of years. The benefits in overall cow sanitation are very easy to visualize. A client of one of my good friends told me when I was visiting his dairy that docking tails was one of the best management procedures that he had ever made. As he put it "It improves everyone's attitude. They don't hit me and I don't hit them."

Some dairymen have attempted to dock tails on young heifers. It is difficult to leave a consistent amount of the tail when young animals are docked. The best time to dock tails is when heifers have reached relatively mature size - anywhere from 4 to 6 months before freshening on up to freshening. However, animals can be done at any age and it is not uncommon for a whole herd to be banded at one time. The goal is to leave approximately two hands' width of tail below the lower lips of the vulva. It is important to not dock the tails too short because the stub will open the lips of the vulva and frequently result in excessive contamination in the vaginal area. Also, if the tails are docked two hands' length below the vulva, there is much less tail to physically remove so there is less chance of having problems with secondary infections and tetanus. Good advice would be to vaccinate the herd for tetanus prior to the time the tails were docked. I know of many dairymen that have docked complete herds without having done any tetanus vaccination at all and not really had any problems. Several Veterinarians have told me that they have had one or two animals develop tetanus that were not vaccinated prior to removing the tail. Most dairymen use an elastrator band around the tail which results in minimal discomfort for the first few minutes and then no apparent discomfort on the part of the cow. Tails generally take from four to seven weeks to fall off after the band has been placed on the tail.

SINGEING UDDERS

Advocating this technique has gotten me in some hot water from some animal rights people. However, it is the best method that I have found to keep udders free of hair.

The technique that I would recommend to use is a plumber's style propane torch and completely block the air inlet ports at the base of the brass burner. You do this by using a small piece of aluminum foil twisted very tightly around the base of the burner. You may need to put a couple of small wires around to firmly hold the foil in place. Once the air vents are blocked off, light the torch. If the flame is of orange consistency with little or no blue flame, then you are ready to proceed. You need to remember to keep the barn or parlor well ventilated. The smell will get to you quite quickly if you don't. Hold the torch approximately 12-14" below the cow and do a little bit of experimenting as to the exact distance needed and singe off the hair on the floor of the udder and around the teats. Do not try to remove all of the hair from the udder but just that hair immediately surrounding the teats and the floor of the udder. By removing this hair, it is much easier to clean the teats because manure and organic material do not have anything to cling to when the animal lays down. In my experience, cows tolerate this burning much better than clipping with a cow clipper.

UDDER PALPATION AND TEAT END EXAMINATION

Many of us involved in production medicine need to get back to the basics of doing a good physical exam. One of the best services that you can offer your clients is to examine the monthly somatic cell count sheets, take them into the barn and then examine the teat ends and palpate the udders on some of the high cell count problem cows. You really don't need to culture many chronic Staph aureus cows to confirm that palpation can reveal 90+% of these type cows. I especially like this technique at morning herd checks fairly soon after the morning milking. Also, carry a small, high powered flashlight to examine the teat ends closely. I really become quite concerned if I see damaged teat end skin, excessive cracking or a hyperkeratinization resulting in a cauliflower-like appearance to the end of the teat. I am of the firm opinion that the healthier the teat end skin, the lower the new infection rate will be. I have been involved on enough farms to know that you really need to look at the teat ends to determine if, in fact, excessive irritation is taking place.

FREESTALL DESIGN

In the mid-seventies, Dr. Jim Jarrett from Rome, Georgia developed a freestall that I commonly call the Jarrett Freestall. Basically, this is an eight foot long freestall that has a breastboard installed 5'6" into the stall from the outside of the rear curb. I have seen this stall installed in new facilities made completely of cement. However, I often use the Jarrett design to retrofit existing stalls, especially those bedded with sand or limestone. Breastboards can be made of old telephone poles, power line poles, railroad ties or any other lumber that dairymen can come up with. In sand or limestone stalls, it is very easy to dig a small trench and then put in used railroad ties, etc. Be sure to have proper slope in the total freestall, then dig a trench for the railroad tie to go in and then pack the railroad tie in using some type of a mechanical tramp or some device to pack the bedding material very tightly around the railroad tie or pole or other construction timber. I then advise clients, if they are bedding with sand or limestone, to put a fairly large volume of these materials in front of the breastboard as a supply to facilitate frequent cleaning and maintenance of the freestall. If breastboards are installed on cement stalls, they can be constructed of two by six treated lumber or any of the timbers that we have already talked about can be used if they are braced adequately to the front of the stalls. If you retrofit cement stalls and the dairyman is using some type of bedding, either chopped straw, chopped newspaper, cornstalks or whatever, again, have them put large amounts of the bedding in front of the breastboard to use as a supply site to maintain the stall. One of the best recommendations you can make to your clients is to have them hang a garden rake at each of the doors in the freestall with instructions that anytime anyone enters the freestall, they pick up the garden rake and maintain the stalls on their way through. I do an extensive amount of consulting and I have watched people bring cows in their freestall barns into holding pens at milking time. Dairymen that have their cows trained properly, in my mind, go into the stalls with their garden rake, the cows see them coming and begin a slow methodical movement to their holding pen. Contrast this to the guy that goes into the freestall barn with a short section of milkhose screaming and yelling at the cows and watch how the cows take the corners and end up in a really filthy condition when they do reach the holding pen.

ENVIRONMENTAL ASSESSMENT

It is extremely important to take the time to physically go out and examine the areas where cows live between milking. How many of you can honestly say that you have been into all of the facilities and all of the pastures and small paddocks that your dairy clients use. I think it is extremely important, at least a couple of times of the year, especially during times of inclement weather or changing weather patterns, to go out and physically examine where the cows live. I have seen some tremendous problems created where concrete ends and where a drylot begins. Not only are the cows subjected to trauma but they are also forced to walk through septic tanks. Additionally, by going out periodically and evaluating the overall environment, you can make an assessment as to the water quality that their animals receive. I routinely recommend to clients that they install large water tanks such as old bulk tanks, old cheese plant tanks or the commercially available large stock tanks. Preferably these tanks are located near exits of parlors or in an area in the direct sunshine where the water will warm up considerably during most months of the year. The problem that many dairymen have with these large tanks is that they work real well when they are first installed but maintenance on them falls far short of being desirable. These tanks should be cleaned on a periodic basis and then at least once per week chlorox or bleach should be added to the tank at a rate of one ounce per ten to twenty gallons of water. You can come up with tables to give you estimates on stock tanks as far as their gallon capacity to estimate the amount of chlorox to use. In addition, you should have dairymen clean water fountains on a regular basis and place five to six ounces of chlorox in these fountains on a weekly basis to facilitate maximum water intake which will yield higher dry matter intake and, therefore, more production.

This has been a brief pot pourri of practice tips relating to the production of quality milk. I think the overall theme that I have tried to deliver today is that it is extremely important for each and everyone of us to become actively interested in this area for the sake of our clients and the sake of our future as dairy practitioners. There is no substitute for being on the farm on a regular basis and being observant to the potential problems that may lie in the environment where the cows live and where the milking is done. Too many times dairy veterinarians tend to blame the milking machine or some other factor and allow the production of quality milk to not be a top priority. I think with the current consumer pressure and monetary incentives from milk procurement plants, it is certainly time that we realize the impact that we can make on the production of quality milk.

Mastitis Control Based on Specific Diagnosis

Ralph J. Farnsworth
University of Minnesota

The general tendency in approaching mastitis herd problems is often one of making numerous rather general recommendations. These often include factors such as improved sanitation, examination of milking equipment, teat dipping and dry cow treatment. While it is important that all factors be considered this approach often leaves the dairyman with a long list of general recommendations and often with no clear cut idea of the relative importance of the various factors.

To consider mastitis as a single disease is analagous to "shipping fever" without consideration of the quite varied aspects of the etiologic agents involved in this complex of respiratory diseases.

A great variety of organisms have been shown to be responsible for mastitis cases and outbreaks but many of these organisms have only been isolated in a few instances. In reality a relatively small number of common species are involved in the vast majority of mastitis herd problems. The pathogenesis of these organisms is well understood and the various factors usually associated with their successful infection are generally known.

The diagnosis of mastitis on a herd or individual cow basis by use of indirect methods such as somatic cell counts, or CMT is commonplace. The amount of information about the problem which can be obtained from these methods varies with the method of testing and utilization of the information. A high cell count from a herd simply indicates the problem is present and the duration can sometimes be determined. While individual cows somatic cell counts from the DHIA program which are also further broken down into type of cow, stage of lactation etc. can be much more helpful in the determination of the possible source of the problem. Diagnosis of the specific type of organism involved in the herd problem can be accomplished by several methods. However this determination is frequently not made or done in such a way that misleading information is obtained. Cultures of quarters with clinical mastitis is one method which can be used. However there are several problems associated with this system. Unless the samples are taken at the proper time the results may be negative or the organism that is causing clinical mastitis cases may not be the major herd problem. Cultures from the whole herd would appear to be the most accurate system of determining the major pathogen involved in a herd problem. But several problems are also encountered using this system. First the method requires a large number of samples to be examined which results in the need for extensive laboratory facilities or high service charges. Also organisms which cause chronic infections will be detected, but organisms which cause acute cases of short duration can be missed and a false idea of the true problem, especially for the environmental component. The use of a screening method such as a CMT or somatic cell counts will reduce the number of samples which must be examined but may also result in missing some early infections. In general, however this method will result in a relatively similar picture to whole herd culture. Obtaining samples from a representative group of cows is another method which can be used. Approximately 12 cows from a herd selected equally from the following groups should be used.

1. Cows with clinical mastitis.
2. Cows with previous mastitis but presently normal.
3. First calf heifers.
4. Older, clinically normal cows.

Because of the limitations of each of the above methods, the sue of a combination of some of each is probably the most practical and accurate.

The use of the bulk tank cultures has also proven useful particularly in determining the potential for infection with environmental organisms. The method presently being used is described as follows.

1. Five consecutive daily samples are collected in syringes or vacutainers.
2. The samples are frozen each day immediately upon collection.
3. Samples must arrive at the laboratory frozen.
4. The samples are vortexed from mixing and an aloquet from each used to make a composite sample.

5. The composite sample is plated on differential media in 3 dilutions to obtain an actual count of organisms.
6. The number of organisms is calculated for
   1) streptococcus agalactia
   2) staph aureus (coagulase positive staph)
   3) non agolactia streptococcus
   4) coliforms
   5) staph epidermis (coagulase negative staph)

These numbers can be compared to this table which has been developed based on experience in numerous herds where the results of bulk tank cultures have been compared to on site evaluations.

	Bacteria Counts			
Type of Bacteria	Low levels levels	Moderate levels high	High	Very
Strep Ag	0-50	100-200	200-400	400
Staph Aureus (coag. pos.)	50	50-150	150-250	250
Non-Ag Strep	500-700	700-1200	1200-2000	2000
Coliforms	100	100-400	400-700	700
Staph sp. (coag. neg)	300	300-500	500-750	750

Interpretation of Results

The organisms generally causing mastitis problems can be divided into 2 general categories based on their source. Streptococcus agalacti and staphylococcus aureus are residents of the mammary gland and the primary source of these organisms is the infected mammary glands of other cows. In general these 2 types of infections can be considered as contagious, infectious diseases and it can be assumed where these organisms are involved, they are coming primarily from infected quarters.

Non agalactiae strep, coliforms and staph epidermis are obtained primarily from the environment of the cow. The presence of these organisms on quarter samples can indicate either infection or contamination. The presence of the organism along with an increased cell count (750,000+) or repeated isolation indicates infection rather than contamination. In the case of bulk tank samples when these organisms are in higher than normal numbers is most often from external sources rather than infected quarters. Thus for environmental organisms this system provides more information on the sanitation and milking practices than on individual quarter infection. However experimental evidence is available to indicate, that high numbers of organisms at the teat end increase the chances of these organisms gaining entry to the quarter in sufficient numbers to cause infection.

Streptococcus agalactiae

If high levels of streptococcus agalactiae are found the following factors are the most likely faults to be found in the herd. There are often defects in the practices which limit the spread from cow to cow. Things such as the use of common udder washing cloths, the use of common teat tubes and lack of teat dipping or inconsistent teat dipping as well as the use of ineffective teat dipping practices. The use of milking equipment which is inadequate in capacity or improperly functioning may also accompany strep ag infection. Failure to dry treat is also often a factor in strep ag herd problems. Bulk tank sample counts above 1,500 tend to indicate a few cows shedding enormous numbers of organisms rather than all cows in the herd being infected.

Staph aureus

High numbers of staphylococcus aureus infected quarters result from generally the same types of factors in the case of strep ag. Anything that enhances cow to cow spread. The role of teat dipping in this infection is similar. Traditionally milking equipment has been blamed in the case of staphylococcus infection. Equipment should be checked, but staph infection is not pathognomonic for equipment problems. Incidences have been noted where equipment problems were present but later resolved. however a large number of cows become infected and this produced such a severe exposure that the high infection rate continued after correction of the problem. In this instance culling may be necessary to reduce exposure. In recent years the value of a milking order preventing staph has been emphasized.

Non agalactiae streptococcus

This category includes all streptococcus other than strep agalactiae. The major significant organisms are strep uberis, and strep dysgalactiae. Isolation of a large number of these organisms from samples without an increase in cell counts or from bulk tank samples is an indication of excessive contamination but does indicate a potential for infection. Improper cow preparation, such as poor washing, plus excessive use of water with no drying appears to be the most frequent cause of excessive numbers of these organisms. Muddy lots and poor stall management and drainage can also provide excessive contamination. In most instances the numbers of these organisms are more a reflection of environmental condition and management than infection. In some instances chronic infections with strep uberis may also give high numbers.

Coliforms

The numbers of coliforms obtained from bulk tank samples or milk samples from cows other than those with clinical mastitis also tends to be more of an evaluation of environmental situation than the rate of quarter infection. High numbers of coliforms tend to indicate poor stall sanitation, contamination of bedding, such as sawdust and excessive growth as occurs in humid weather, or cows being poorly washed and dried after excessive coliform contamination. This situation again has the potential for increased infection rates.

staph epidermitis

This organism is a normal skin flora and is not considered to be as pathogenic as staph aureus. High numbers of this organism tends to be associated to some extent with poor cow preparation practices, such as no washing or lack of use of disinfectant but is primarily associated with lack of teat dipping or the use of ineffective teat dipping practices such as shallow dip cups or spraying. This organism tends to be an indicator in that it shows flaws in practices rather than being associated primarily with infection problems.

If the above situations are kept in mind when evaluating the microbiology it is possible to zero in on the specific problem which allows minimal changes in management to be made while concentrating on the most important factors relative to the herd problem.

MIXING AND PLATING PROCEDURES

Preparing Composite Sample

1. Thaw frozen samples in refrigerator for approximately 12 - 24 hours.

2. Mix each sample well. Invert each sample 15 times or place in Vortex mixer for 5 to 10 seconds.

3. Transfer 5 ml of each days sample by sterile pipette to a single sterile tube labeled by farm name or number and "C" for composite.

4. Mix this composite sample well by inverting 15 times or place in the Vortex mixer for 5 to 10 seconds.

5. Allow media plates to come to room temperature prior to inoculation.

Preparing the 5X dilution plates

6. Pipette 0.2 ml of the composite sample onto each of the plates labeled with the sample number followed by a dash and 5 to indicate dilution. Spread over the plate evenly using a single sterile glass spreading rod.

Preparing the 50X dilution plates

7. Pipette 0.2 ml of composite milk into 1.8 ml of sterile diluent and label 50. Mix this well by inverting 15 times or place in Vortex mixer for 5 to 10 seconds.

8. Pipette 0.2 ml of the diluted milk onto plates labeled with the sample number followed by a sash and 50 to indicate dilution. Spread over the plate evenly using a single sterile glass spreading rod.

Preparing the 500X dilution plates

9. Pipette 0.2 ml of above diluted milk into 1.8 ml of sterile diluent and label 500. Mix this well by inverting 15 times or place in Vortex mixer for 5 to 10 seconds.

10. Pipette 0.2 ml of the diluted milk onto plates labeled with the sample number followed by a dash and 500 to indicate dilution. Spread over the plate evenly using a single sterile glass spreading rod.

Incubation of plates

11. Invert plates and incubate at 37 C for 24 hours. Read plates and record data.

12. Replace plates in incubator and read again at 48 hours.

PLATE READING

1. Allow plates to stand at room temperature for 15 to 30 minutes before reading. This will enhance coloration caused by esculin-splitting Streptococci. Select a plate of each type that has from 10 to 300 colonies for counting.

2. MacConkey: Count all pink colonies. Pseudomonas will appear as a colorless colony and should be checked with the oxidase test. If positive oxidase, count these as well. Multiply the total count by the appropriate dilution factor of 5, 50, or 500.

3. TKT:
   a. Strep. ag. are hemolytic, colorless colonies. Count and multiply by appropriate dilution factor.
   b. All other non-hemolytic Streptococci are totalled and multiplied by the appropriate dilution factor.

4. KLMB: Count all 3-5mm yellow-white colonies with a clear zone of beta hemolysis, multiply by dilution factor, and record as Staph. aureus. Count all other colonies with similar morphology, but no hemolysis, multiply by the dilution factor, and record as Staph. epi.

5. TSA with 5% Sheep Blood Agar: Count all colonies and multiply by the dilution factor. If there are more than 300 colonies at all dilutions, record as too numerous to count (TNTC).

Bulk Tank Mastitis
Microbiology

Bulk tank cultures are available from the Minnesota State Veterinary Diagnostic Laboratory as of August, 1981.

SAMPLE COLLECTION

Sample collection, storage and transport are extremely important when using bulk tank analysis, and any incubation renders the samples unusable. To help prevent inaccurate results, samples are screened by pH and any which appear to have incubated will not be tested.

To avoid daily variations five samples are required. Samples should be collected for five consecutive days at the same each day. The milk in the tank should be well mixed before the sample is collected--(after millking is a good time). Samples should not be collected from the outlet of the bulk tank.

Samples can be collected in a sterile container such as syringes or vacutainers. Syringes should be new or heat sterilized to avoid chemical residues. If syringes are used they should only be filled one-half full to avoid the plunger being pushed out when the sample is frozen. Place the sample in a freezer immediately after collection. No more than five minutes should elapse from collection until the sample is placed in a freezer.

Samples must be transported in such a way that they do not thaw in transit. They should be packed in dry ice if shipped via mail or parcel delivery. Avoid weekends and holidays.

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*See back of this sheet for a step by step method for collection of bulk milk samples for mastitis examination.

(over)

Step By Step Method
For Collection of Bulk Milk Samples
For Mastitis Examination

1. Obtain proper sterile sampling equipment.

2. Sample at the same time each day for five consecutive days.

3. Allow the agitator to run until milk in the tank is thoroughly mixed.

4. Obtain sample directly into syringes or sample tubes.

5. Obtain sample from top of tank or allow sufficient milk to run through discharge pipe to be sure sample is from tank proper and not the discharge pipe.

6. If syringes are used, only fill half full.

7. Place sample in freezer within five minutes after collection.

8. Transport sample to lab in dry ice or large amount of ice in an insulated container.

THE DAIRY PRACTITIONERS' OPPORTUNITY TO IMPROVE THE COW'S ENVIRONMENT

Gordon A. Jones, D.V.M.

Performance is the new standard that dairy farms and dairy practitioners are being judged by. Everyday, a dairy practitioner has opportunities to view subpar performance of both the dairy livestock and the total system (housing, ventilation, feeding, cattle handling, etc.). Taking these opportunities and giving leadership to the dairy farm is rewarding to both the veterinarian and the dairyman.

There are four major reasons for improving the environment. First, we can improve the animal's health, both clinically and subclinically. Healthy animals are needed to perform optimally but they are not necessarily profitable animals unless managed profitably. Second, we can improve and measure the improvement of the animal's performance, i.e., pounds of milk per cow per day, rate of gain, reproductive efficiency and labor efficiency. Third, we can improve the operator's health and safety. The last reason is that we can improve the building's health and longevity.

As veterinarians, usually our first visit to the dairy farm will be to treat sick animals. When we treat animals with diseases caused by poor environment, it is frustrating and unprofitable to treat only the effect and not the cause of the disease. By relating the disease to the environment, we now have the opportunity to educate the dairyman and discuss ways to improve the conditions. There are many times when I use the dairyman's health and or the building's health to make major changes in the cow's environment. The dairyman sometimes has a tough time seeing that if we make major changes in his buildings that he will get a payback from improved performance of his animals. It is sometimes easier to demonstrate that if we don't make changes in his building, they will not last too much longer. This is very true for any building that is poorly ventilated. In a cold building with inadequate ventilation, look for condensation or water marks on the ceiling and dripping or staining from the purlins. These are tell tale signs that not only is the animal's environment not good, but that the building is also not as healthy as it should be.

Cow performance increases as the environment becomes more cow friendly. Many times, the environment may be healthy enough to keep the cow healthy, but not friendly enough to increase performance. The single most important performance measurement, may be dry matter intake (DMI). As dry matter intake increases, performance increases. Areas of attention in the environment to increase cow friendliness, thereby increasing DMI and cow performance are; air quality, stall space, bunk type, bunk space, bunk surface, number and placement of waterers, and floors.

Improving air quality in cold, naturally ventilated barns can be as simple as opening the ridge (2"/10 ft of width), opening the eaves (1"/10 ft of width) and removing the sidewalls for the summer. In warm, mechanically ventilated barns, air quality can be improved by insuring four air exchanges per hour in the winter and increasing to forty air exchanges in the summer. The addition of basket or torpedo fans does not increase the air quality but increases the cow's comfort. The major mistake in warm barn ventilation is not the number of fans present but the lack of adequate and proper air intakes.

Inadequate stall size reduces cow comfort and DMI. Making stalls clean, dry, well bedded, and of adequate size will increase cow comfort and milk production. Stall sizes vary depending on breed and size of animal. Check the Midwest Plan Service book for correct sizes.

Bunks and mangers need to be lowered to the natural grazing height. This increases saliva production and takes advantage of natural buffering of the rumen. Cows fed at a fence line bunk spend 26% more time eating than those cows fed at a smaller elevated bunk which they could travel around easily.[1] Manger surfaces should be smooth, slippery, and cleaned daily to encourage increased feed intake. I recommend a minimum of 2 foot of bunk space per cow to insure maximum DMI.

Waterers need to be clean and free of debris. There needs to be one waterer per 20 cows and at least two waterers per group of cows. This insures that no one cow will control the other cow's water intakes. Waterers should not be deeper than six to eight inches, to insure freshness and cleanliness.[2]

Flooring needs to be firm and sure. Cows should not be afraid to walk around. This insures travel to the bunk for food and water and increases the likelihood of heat detection.

Where does the Veterinarian look for the correct information on these areas of interest? Good sources of information are; 1-"Dairy Housing and Equipment Handbook", Midwest Plan Service, Iowa State University, Ames, Iowa 50011; 2 - "Dairy Housing II", Proceedings of the Second National Dairy Housing Conference, ASAE, 2950 Niles Road, St. Joseph, Michigan 49085; 3 - "Livestock Environment II", Proceedings of the Second International Livestock Environment Symposium, SAE, St. Joseph, Michigan 49085; and 4 - Your Extension Dairy, Ag Engineer.

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AN APPROACH TO SOLVING FEEDING PROBLEMS ON DAIRY FARMS

J. G. Linn and D. E. Otterby
Department of Animal Science, University of Minnesota

A feeding program on a dairy farm consists of the following: feeds, ration formulation, feed mixing, delivery of ration to cows and, finally, consumption of the feeds or ration by cows. The successful feeding program correctly controls and integrates all of these. When a breakdown or slippage occurs, herd performance becomes limited. Most often it is a combination of elements within the feeding program that limits performance and not just a single element. When evaluating a feeding program, it must be broken down into its elements and analyzed separately, not as a whole. The objective of this paper is to identify some of the factors to consider in evaluating feeding program elements where potential milk production is not being achieved.

FEEDS

For most upper midwest dairy producers, more than 60% of the dry matter (DM) consumed by cows comes from home-grown feed supplies. Thus, controlling the quality of this portion of the cow's ration is of utmost importance and under direct control of the producer. Variation and/or poor quality in home-grown feeds limits milk production and creates problems throughout the feeding program.

An example of a typical Minnesota dairy ration is in Table 1. Forages account for 55.5% of the ration DM and provide 63% of the crude protein (CP), 48% of the net energy (NE_L), 91% of the acid detergent fiber (ADF), 64% of the calcium (Ca), and 27% of the phosphorus (P) contained in the ration. Add the high moisture shelled corn (HM corn) to the forages and over 90% of the DM in this ration comes from home-grown feeds. Quality problems with any of these feeds will not only limit production potential but also increase ration costs as producers buy other feeds or feed supplements to compensate for home-grown feed inadequacies.

Home-grown feeds must be analyzed for nutrient content. The first step in a good analysis is obtaining a representative sample of the feed to be analyzed. Baled hay must be probed with at least 15 bales being probed from the defined lot of hay. Probing a half dozen bales of hay in the hay mow will not provide a representative sample. Ensiled forages should be subsampled over 3 to 4 feedings and combined to obtained the best estimate of quality. Sampling one feeding is insufficient.

When looking at forage test results, know what to expect. Legumes should be high in CP (18-22%) and Ca (over 1%) and between 28 to 40% ADF on a DM basis. Corn silages should contain 8 to 12% CP, around 25 to 35% ADF and be low in Ca (.2 to .3%). Energy values will vary depending upon the equation the laboratory uses to calculate them, but remember fiber (ADF or crude fiber) and energy content are inversely related.

All feeds should be examined closely for mold, color changes, unusual smell and for physical form. Dry feeds as well as ensiled or high moisture feeds are subject to quality deterioration during storage. Molding and heating are the two most common detrimental quality changes. Determining the exact problem and to what extent the problem occurs from feeding moldy feeds is almost impossible, but consumption of moldy feed by cows has been linked to decreased milk production, low fat tests, reproduction problems and general health problems.

The heating of feeds during storage results in feeds becoming dark brown to black in color and having a tobacco type aroma. Heated feeds are often consumed readily but performance is usually depressed because the protein and energy available to the animal from the feed is reduced. Heating is usually a result of ensiling feeds too dry. The opposite, ensiling feeds too wet, results in sour or acid feeds. Wet feeds are usually light in color, have a butyric acid or sauerkraut smell and often feel slimy. Cattle generally do not consume wet feeds very well.

Physical factors affecting quality of feeds are such things as particle size of forages and the processing of grains. A guideline for forages is that a handful of forage should have over 50% the particles over 1.5 inch in length. The moisture content will affect this guideline somewhat, but there must be adequate particle size in either wet or dry forage to stimulate good rumination. Grains should not be ground or processed into a flour. High moisture shelled corn that has been processed correctly has the kernels split into thirds.

Some general guidelines for evaluating feeds and feed quality problems are:

1. Be sure all home-grown feeds have been correctly sampled. A recent analysis of the feeds, within 2 weeks of the problem, is needed.

2. Review analyses and question variations.

3. Look at feeds for color, mold and physical characteristics.

4. Look at the cows for:

    a) What they are eating and how are they eating it? Cows sorting through feeds and infrequently taking mouthfuls indicate feed quality problems.

    b) How many are chewing their cud? A guideline is 50% of the cows lying down should be chewing. If particle size is inadequate and grains overprocessed, chewing time is reduced. Milk fat tests will be lower than their maximum potential.

RATIONS

Two key elements are involved in formulating a ration; the nutrient content of feeds and the DM intake of the cow. If either the nutrient content of feeds or DM intake of the cow is over or under estimated, intake of nutrients will not be in balance. Profitable production will not be achieved because of either less than maximum performance or greater than necessary feed costs. The purpose here is not to learn how to formulate rations but identify some of the factors that must be considered when evaluating feeding programs.

Most often producers have a balanced ration, on paper, provided to them from a feed company, extension or feed consultant. One of the first things to check when looking at this ration is to see if it contains at least one each of the following feed categories:

Forage
Grain
Protein supplement
Calcium - Phosphorus mineral
Salt
Vitamin and trace mineral source

Some feeds may overlap into several of the categories. For example, a commercial mineral may provide calcium and phosphorus, salt, vitamins and trace minerals. All feed tags should be collected and reviewed to determine nutrient contributions from commercial feeds.

The next step in evaluating a feeding program is to calculate the potential milk production of the average cow in the herd from feed analysis reports, feed tags and feed amounts fed. Milk production potentials should be based on net energy-lactation and protein as these two nutrients most likely are controlling milk production. The calculated potential should be within 2 to 4 lb of the actual production. If it is, then the feeding program is performing as projected. If actual milk production is more than 4 lb from the calculated potential, then some changes in the feeding program are necessary or better feed intake information is needed. Actual productions higher than potential indicate cows are either consuming more energy than projected or they are losing body weight to support production. Early lactation cows will normally lose 1 to 2 lb per day of body weight to support 7 to 14 lb of milk production per day. In this situation, the ration may not be incorrectly formulated or fed. When actual milk production is below projected potential, rations must be checked for total nutrient balance and feed intakes must be determined.

Body condition scores. One part of troubleshooting ration problems is evaluating the body condition of cows. If cows in general are thin (mid 2's) but milking as projected, it is an indication the energy density of either the early lactation ration or late lactation ration or both is less than required. General overcondition in the herd indicates overfeeding for the genetic potential of the herd or other nutrients, particularly protein, in the ration are deficient. The recommended body condition scores of cows at the suggested scoring times are as follows:

Calving	3.5
Peak milk	2.5
Mid-lactation	3.0
Dry off	3.5

Nutrients. The nutrients most likely limiting milk production are net-energy-lactation, protein and fiber. Minerals and vitamins are most likely not production limiting nutrients in today's dairy herds. The exception being salt, where not feeding or overfeeding can reduce DM intake. The recommended nutrient content of rations for dairy cows is in Table 2.

An excess or deficiency in the energy content of a ration can cause less than projected performance. Increasing the energy density of a ration may not achieve increased energy intake because total ration DM intake may decline. Energy densities of .78 to .80 Mcal/lb of DM are considered sufficient for cows in early lactation. Maximum DM intake along with adequate fiber intake can be achieved within this energy range. Increasing the energy density of a ration above .8 Mcal/lb generally results in insufficient fiber intake and the appearance of loose manure and acidosis or off-feed problems in cows. Insufficient energy or low energy density in a ration is often indicated by a dry, solid manure. Rations most often exceed the minimum fiber recommendations also.

The correct amount and type of protein in the ration is necessary for optimal energy utilization and also has a stimulating affect on feed intake. It is important to meet CP requirements first and then fine-tune rations for degradable and undegradable protein content. Shortages of degradable protein starve rumen bacteria for ammonia which decreases bacterial growth decreasing digestion of carbohydrates and fiber. Dairy rations should have a minimum of 55% of the CP as degradable protein. On the other hand, excessive amounts of degradable protein, above 70% of the CP, can result in high rumen ammonia levels which cannot be converted back into bacterial protein rapidly enough to prevent wastage of protein via urinary excretion.

Both the amount and physical form (length of particle size) of fiber in the ration is important. The physical characteristics have been discussed under the feed section, and recommended amounts of fiber in rations are in Table 2. Rations deficient in either amount of fiber or in effective fiber particle sizes will often result in good milk productions with high milk protein tests but low fat tests. Fluctuating feed intakes, acidosis and off-feed problems are also very likely.

Feed intake. There is no substitute for the actual weighing of feeds fed to determine feed or DM intake. How much does a fork full of silage or scoop of grain weigh? The answer is different on every farm and different on any one farm depending on who is feeding and the moisture content of feeds. Total accuracy on how much cows consume will never be achieved on farms but weighing feeds will provide a much more reliable intake figure than a computer estimated value. A weight or volume-weight measure should be obtained on all individual feeds fed. If a grinder mixer, total mixed ration (TMR) or other type of feed weighing device is used, the accuracy of their scale must be checked periodically.

How much feed should cows consume or how much feed do cows consume? These are two different questions. The 1989 NRC-Dairy DM intakes are how much cows need to consume to meet the nutrient requirements listed in the publication. How much are cows actually consuming is the question that needs answering on the problem farm. The answer to this question can then be compared to projected intakes. DM intakes below those in Table 3 are low and reasons for the low intakes should be sought.

Some reasons for low DM intakes other than nutrient content of the ration and feed quality are:

1. Moisture content of ration - Cows generally cannot consume more than about 100 to 110 lb of as fed feed per day. If cows are to achieve DM intakes of 55 to 65 lb per day, the moisture content of rations cannot exceed 50%. Moisture contents below 30% may also be too dry and adding some water or a wet feed to the ration may increase DM intake, especially if a TMR is fed.

2. Feedbunk management - How often are the bunks cleaned out and by who? If cows clean the bunks, they are not on full feed. Bunks should be cleaned out every other day by the producer or person in charge of feeding. No feeds should build up in the corners or on the bottom of the bunk. New fresh feed should never be put into a bunk on top of moldy, heated or stale feed.

3. Feed availability - Feed bunks should never be empty more than 30 minutes a day. Cows should not have to be in holding areas, milking parlors or exercise lots away from feed for more than 6 hours per day. High producing cows should have feed available at all times if maximum production is to be achieved. Cows should not have to walk long distances to obtain feed.

4. Feed bunk space - All cows should be able to eat at once. A minimum of 30 inches per cow is required. If feed bunk space is a problem, the low production group should be reduced in space per cow and not the high production group.

5. Water availability - Ideally water should be available to cows at all time. Locate water sources close to feeding areas. Even moderate restrictions in water intake can significantly reduce DM intake and milk production.

6. Feeding frequency - Frequent feedings will help stabilize rumen fermentation and keep feeds fresher which should encourage DM intake. However, total DM intake over a 24 hour period may not be different between cows fed several times per day versus twice daily. Keeping feed fresh will have the most affect on intake. To avoid rumen fermentation fluctuations feeding

individual feeds 4 times or more per day is recommended. Total mixed rations can usually be satisfactorily fed twice per day.

7. Environment - Temperature, ventilation and slippery floors can all depress feed intake. Be sure these conditions are not limiting time cows spend in the feeding area. Social interaction, especially between older cows and first calf heifers, can also reduce feed intake. Separate heifers into one group, if possible.

FEEDING METHODS

There are two basic feeding methods: all ingredients mixed together or all ingredients fed separately. On most dairy farms, some combination of these two comprise the feeding method. If all of the items discussed previously were controlled and functioning correctly, feeding methods would have little or no affect on performance. However, in most problem situations, the feeding method is confounded with the previous items and therefore needs individual consideration in the evaluation of feeding problems. The intent here is to briefly identify some of the more common problems associated with each method and not discuss the advantages or disadvantages of methods.

Total mixed ration (TMR). - Interest and use of TMR's is increasing. While they are considered one of the best ways to feed cows, they can also cause problems if not managed correctly. The most frequent problems associated with usage are:

1. Not testing moisture content of feeds, particularly forages, frequently enough. High moisture feeds should have a moisture analysis weekly or more often if necessary. Undetected changes in moisture content of one or several feeds in the TMR can drastically change the nutrient balance of the TMR fed.

2. Individual cow or group intakes are not important as TMR's are formulated on a batch basis. This assumption is false as batch weights are based on cow or group intakes. The opportunity here is to be more accurate in obtaining cow or group intakes and therefore more accurately formulate rations.

3. Not knowing what production or production levels at which to balance ration(s). The correct level will vary depending on production, stage of lactation and number of groups, but generally 15 to 20% above the group average is adequate.

4. Grouping cows by only one criteria. Milk production, age, fat test, body condition and, possibly, reproductive status should be used as grouping criteria.

5. Accuracy of weighing feeds into mixer is not always good. Many times a conveyor is full of feed when the desired weight for that feed in the mixer is achieved but the additional conveyor feed is added anyway. This extra feed unbalances the ration from the prescribed formula.

Individual grain feeding. There are numerous feeding options associated with this method. Grain can be fed by hand, computer or some other type of mechanized system. Forages can all be fed individually, or some individually and some mixed together. The general problems associated with this method of feeding are:

1. Grain amounts are thought to be known. Be sure scoops or grain feeder calibrations and accuracies are checked. Scoop weights or computer delivered weights are many times different than what they are thought to be.

2. Two distinct problems can be associated with computer grain feeding. The first problem is location of the feeder. Feeders need to be located in an easily accessible area where all cows can get to them without having to walk long distances. The second problem is frequency of updating grain feeding allocations. Weekly, or more often, adjustments are needed to effectively utilize feeders.

3. Forage amounts consumed are almost always unknown. Most often they are calculated by difference from projected DM intake minus the grain DM fed. Many of the problems encountered here are described under feed intake.

Some other points related to computer feeder usage are: feed enough grain through the feeder each day to keep a cow interested in coming to the feeder (5 lb per cow per day minimum); grains or grain mixes must be highly palatable; feeding grain in locations other than the feeder tend to diminish the use of the feeder by cows and, therefore, good bunk management is necessary to keep cows on full feed but hungry enough to use the feeders.

SUMMARY

An attempt has been made to identify some of the common sources of feed programming problems on dairy farms and a systematic, logical approach to identifying these problems. Ration formulation can be a problem but more often it is the quality of feed ingredients or the mixing and delivery of feeds to cows or restricted consumption of the ration by cows that are the limiting elements in meeting the nutritional needs of cows. Reformulating rations when one or more of these other elements is the problem will result in no change in the situation. If cows have only limited access to the ration, the best formulated ration will not increase production. Use the Feeding Program Identification Chart as a reference guide to identifying feeding problems on farms. Find the limiting elements and then rank them as to their relative importance. Solving the most limiting element first followed by the less limiting elements will result in substantial progress being made in the herd's performance.

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Table 1. Nutrient contributions to typical Minnesota dairy ration.[1]

Ingredients	lb as fed	Dry matter lb	Dry matter % of total	Crude protein lb	Crude protein % of total
Hay	6.00	5.14	11.06	1.01	13.17
Haylage	26.88	13.44	28.91	2.49	32.46
Corn silage	19.05	7.24	15.57	0.59	7.69
HM corn	21.81	16.14	34.71	1.61	21.00
SBM-44	3.65	3.25	7.00	1.62	21.12
Meat & bone	0.75	0.69	1.48	0.35	4.56
Mineral/vit	0.59	.59	1.27	0.00	0.00
Total	78.73	46.49	100.00	7.67	100.00
Ration %		59.05		16.50	

Ingredients	lb as fed	Net energy Mcal	Net energy % of total	A D fiber lb	A D fiber % of total
Hay	6.00	3.27	9.38	1.69	18.04
Haylage	26.88	8.37	24.01	4.85	51.76
Corn silage	19.05	5.08	14.57	2.02	21.56
HM corn	21.81	14.91	42.77	0.48	5.12
SBM-44	3.65	2.75	7.89	0.33	3.52
Meat & bone	0.75	0.48	1.38	0.00	0.00
Mineral & vit	0.59	0.00	0.00	0.00	0.00
Total	78.73	34.86	100.00	9.37	100.00
Ration		0.75 Mcal/lb		20.15%	

Ingredients	lb, as fed	Calcium grams	Calcium % of total	Phosphorus grams	Phosphorus % of total
Hay	6.00	28	16.38	5	5.32
Haylage	26.88	73	42.69	13	13.83
Corn silage	19.05	8	4.68	7	7.45
HM corn	21.81	2	1.17	21	22.34
SBM-44	3.65	5	2.92	10	10.64
Meat & bone	0.75	38	22.22	16	17.02
Mineral/vit	0.59	17	9.94	22	23.40
Total	78.73	171	100.00	94	100.00
Ration %		.81		.45	

[1]Ration for 1400 lb cow producing 70 lb of 3.8% fat milk.

Table 2. Nutrient guidelines for dairy cows.

Item	Stage of lactation Early	Mid	Late
Protein			
Crude, % DM	18-19	15-16	13-15
Degradable, % DM	9.5-10.5	8.5-9.5	7.5-8.5
Undegradable, % DM	6.5-7.5	5.5-6.0	4.5-5.0
Net Energy - lactation			
Mcal/lb DM	.78-.80	.73-.75	.71-.74
Acid Det. Fiber, % DM	19	21	24
Neutral Det. Fiber,% DM	28	32	36
Non-Fiber Carbohydrate, % DM	37-42	34-38	30-35
Fat, max % DM	7	5	3
Calcium, % DM	.8-1.0[1]	.6-.9[1]	.5-.8[1]
Phosphorus, % DM	.5-.55[1]	.40-.45[1]	.35-.40[1]
Magnesium, % DM	.25-.35[1]	.25	.20
Potassium, % DM	1.00	.90	.90

[1]Higher values should be fed when fat is added to diet.

Table 3. Dry matter intake guidelines.[1]

Milk - 4% fat	Cow weight 1100	1300	1500
lb/day		lb/day	
20	26	30	34
40	32	36	40
60	38	42	46
70	41	45	49
80	44	48	52
90	47	51	55
100	50	54	58

[1]Based on intake equation of .0185 x BW (lb) + .3 x 4% fat milk (lb/day). These intakes are conservative. Cows should be consuming these amounts except for during early lactation when intakes may be up to 15% less.

FEEDING PROGRAM IDENTIFICATION CHART

FEED QUALITY

Analysis reports, Feed tags, Forage quality, Physical characteristics, Mold

↓

FEED WEIGHTS FED

Weight of forage(s) and grain(s) fed

↓

RATION ANALYSIS

Check for forage(s), grain(s), protein supplement, mineral, salt and vitamins in ration

↓

MILK ACTUAL = PRODUCTION POTENTIAL FROM RATION

YES

↓

Ration is performing expected

↓

Check cow condition

NO

↓

1. Reformulate ration
   - Check feed nutrient values
   - Re-check feed intakes
   - Adjust nutrient content in ration to meet production requirements
2. Feed availability
   - Bunk space - 30"/cow
   - Time cows away from feeding area
   - Distance to feeders or feeding area from loafing area
3. Feedbunk management
   - Empty feedbunks
   - Moldy feed in bunks
4. Social order in herd - 2 yr olds vs older
5. Water availability
6. Feeding frequency
   - Individual - 4 times per day
   - TMR - 2 times per day
7. Environmental factors
   - Temperature
   - Ventilation
8. Condition score early lactation cows, late lactation cows and dry cows close to freshening

CLINICAL CASE REPORTS

submitted by

Dr. Gary D. Neubauer
Nicollet-New Ulm Veterinary Clinic
New Ulm, Minnesota 56073

CASE REPORT #1

SYSTEMIC PROBLEM

FARM: 117 cows, parlor system with free stall housing and a rolling herd average of 16,800 and a SCC average of 220,000.

HISTORY: Problems on this farm started in February 1989 when heifers freshened with non-responsive uterine infections, weight loss, and displaced abomasums. These problems continued through June with successive groups of freshening heifers. Early in July, both high and low milking groups broke with diarrhea of about one week duration. In July, two to four week old calves became ill with fever, listlessness, diarrhea, and dehydration.

MANAGEMENT: The dairy operation has expanded from 80 cows to 117 over the last 2 years, and continues to raise out all their steers. This is a total cemented system with 2 manure lagoons. There is a definite overcrowding and sanitation problem. The herd is bred with 2 different purchased bulls and some AI. The feeding program involves a TMR system. Calves are born in 2 maternity pens and then transferred to individual calf hutches in a converted machine shed. During the end of June and July, there were so many calvings (29) that one of the maternity pens was made into a group calf pen.

FINDINGS: The University of Minnesota diagnostic lab isolated salmonellosis from 3 calves and 2 heifers. The salmonella was identified as serotype 9.12: nonmotile and further identified as salmonella enteritidis by the Minnesota Department of Health. Further investigations by the University of Minnesota epidemiology department failed to identify the source of salmonella (fecals, manure pit, water, feed, and milk filters were all negative on culture).

DISCUSSION: Transmission among cows - after salmonella gained entry into the herd, other cows were likely infected through fecal-oral transmission. This could occur at several places in the free stall barn. Transmission to calves - this is likely to have occurred in two ways. First, the calves likely became infected in the maternity areas which are directly adjacent to the free stalls (including ill cows). Second, because of the heavy calvings in July, a maternity pen was converted to a group calf pen. These calves when later moved to hutches in the machinery shed probably carried salmonella with them. Also, these calves were fed colostrum and raw milk for the first week which is a potential spread of salmonella. Public health risk - salmonella enteritidis is a zoonotic disease which can be spread through raw milk and the feces. Even though the family did drink raw milk and did help treat these sick animals - no one became ill, except for one of the veterinarians working on the case.

SUMMARY: We continued to search for the source of salmonella by culturing individual feed ingredients and then looked at the feed mixing area and other feed areas for possible contamination; unfortunately, we have been unsuccessful. We encouraged reduction of herd size to reduce crowding in free stalls, overflow of manure pits, and overcrowding of maternity pens. Improvement of cow sanitation by reducing herd size, improving cows use of free stalls, improving fly control and twice daily scraping of alleys was instituted. Also, efforts were made to improve the cows immune status by supplementing vitamins A, D, E and selenium during the dry period, along with boostering various vaccination programs. Finally, calf husbandry and sanitation were improved somewhat by clean maternity pens, avoiding overcrowding, ensuring adequate colostrum intake, and disinfecting calf hutches between uses.

DISCUSSION AND SALMONELLOSIS:

SOURCES: Potential sources of on-farm infections include rodents, birds, contaminated water, and pasture with the major sources being feedstuffs and infected carrier animals. Bone, meat, fish and feather meal are often contaminated with Salmonella organisms. Although these products are heated and cooked during processing, they are often recontaminated after processing. These types of meals are conducive to dissemination of infectious organisms to a large population from a single source.

TREATMENTS: There is varying opinion among veterinary clinicians on how to treat clinical salmonellosis. It is agreed that oral or parenteral administration of fluids, electrolytes and buffers is important to correct dehydration and balance electrolyte losses and acid-base abnormalities. Intestinal absorbents and protectants, such as activated charcoal and kaolin, may be helpful in some cases.

The use of antimicrobials in acute salmonellosis, however, is controversial. Antimicrobials do not eliminate the carrier state and may contribute to the development of antibiotic-resistant strains. Results tend to be poor if treatment is not administered until late in the disease; however, a high cure rate is obtained if the proper antimicrobial treatment is begun early.

CONTROL: Salmonella is difficult to control because of its ability to survive in the environment and because of animal carrier hosts. Salmonella is often found in water sources as a result of contamination. Potentially, contaminated and stagnant water sources should be avoided and made inaccessible to animals. The use of fresh water free of organic material may reduce exposure to Salmonella, because it is unlikely that the organism can survive more than 3 weeks in such water, however, Salmonella may remain viable for up to 9 months in pond and stagnant water.

Management of manure should be directed to heating and drying, because Salmonella is sensitive to both of these processes. The bacterium, however, can remain viable on pasture in feces, and in the soil for up to 7 months. Freezing will decrease survival, but some organisms will be viable after thawing. Salmonella-contaminated concrete areas, metal waterers, and equipment should be cleaned and then disinfected with common phenolic, chlorine or iodine-based disinfectants.

Because the stress of transport will cause an increase in shedding of organisms in carrier animals, newly transported animals should be quarantined for 4 weeks after arrival to reduce the chance of exposure of organisms to resistant animals and contamination of the environment.[1]

CASE REPORT #2

ENTERIC

FARM: 35 cows, tie stall barn with a 18,200 rolling herd average, calves raised in elevated calf stalls.

HISTORY: In February of this year, several calves came down with a mild yellow diarrhea at 2-3 weeks of age. This progressed over a weeks time to a blood tinged diarrhea and subsequent death. Treatments included amproluim, corrective mixture, trimethorprimsulfa, gentamicin, electrolytes, and diaproof.

FINDINGS: Fecals and cultures were run for coccidiosis, cryptosporidiosis, and bacteria upon initial visit. Results from our in-house lab revealed a non-hemolytic E. coli and cryptosporidiosis. Upon further investigation, tissue samples were sent to the University of Minnesota diagnostic lab and the diagnosis came back, enteritis due to cryptosporidiosis and attaching and effacing E. coli infection.

DISCUSSION OF CRYPTOSPORIDIOSIS: An ever increasing enteric pathogen in dairy calves.

TREATMENT: The most effective treatment is to avoid overuse of antimicrobial drugs. Keep calves warm, dry and well fed. Expect a slow recovery in 5 to 10 days.

PREVENTION AND CONTROL: Resistant to most disinfectants. Freezing and thorough drying are the most effective. Pens, crates, and utensils should be cleaned with a 5% ammonia solution and dried. Areas cleaned and frozen are probably free of infectious cryptosporidiosis. Adequate immunity through good, quality colostral intake is essential. Finally, human hygiene is very critical since cryptosporidiosis is a zoonotic disease.

DISCUSSION OF ATTACHING AND EFFACING E. COLI: Attaching and effacing E. coli should be considered an emerging new member of major causes of diarrhea in young calves (enterotoxigenic E. coli, rotavirus, coronavirus, cryptosporidia), the organism appears to be widely distributed throughout the cattle population of the north central United States, especially in dairy operations. Whether this is a newly introduced or evolved disease or whether heightened awareness has led to increased recognition is uncertain.

Enterotoxigenic E. coli infection such as K99 is exclusively a disease of the small intestine. In contrast, attaching and effacing E. coli organisms were adherent in small and large intestine, most frequently in the colon.[2]

While attaching and effacing E. coli sometimes occurs as a subclinical infection with very little bloody diarrhea, it is often fatal in calves 1-3 weeks old, especially when seen in conjunction with other enteric pathogens. Others believe that this E. coli may pose a human health hazard through unpasteurized milk and undercooked meat. Finally, there may be a relationship between colostrum quality, the young animal's colostral intake, and the particular E. coli infection. Infection with attaching and effacing E. coli should be considered in young calves with hemorrhagic colitis or when blood is observed in the feces.

CASE REPORT #3

SURGICAL

HISTORY: Adult bovine surgeries performed by the clinic last year included - left displaced abomasums = 303, right displaced abomasums

= 33, c-sections = 13, and exploratories = 58. The surgical protocol used included clipping, surgical scrub using nolvasan, line block of area using lidocaine with epinephrine, drape the area, use of a rubber ob gown, surgical gloves, cold sterilization of equipment using benzall, and use of catgut and vetafil in sterile spools. Procaine penicillin both intraperitonelly and intramuscularly was administered and the incision line was medicated with topazone.

Post surgical complications tended to be very minimal or insignificant. However, starting in August of 1989, the formation of surgical granulomas along the incision line in several animals became evident. The surgeries on these animals were all LDA's that had been performed four to six months prior. The incisions had healed routinely with no signs of problems, the hair had grown back with no visual signs of scarring or complications. Then, approximately 3 months down the line the incision area started to swell and bulge. The swellings continued to increase until some broke open and formed proud fresh like lesions which we referred to as granulomas.

FINDINGS: Sections of these lesions, along with aerobic and anaerobic cultures were submitted to the University of Minnesota diagnostic lab for identification. Results included isolation of Pseudonomas areugenosa.

DISCUSSION: Possible sources of contamination included cold sterilization technique of the equipment, spools of suture material, surgical gown, and local anesthetic.

Changes which were instituted included using lidocaine without epinephrine, autoclaving all surgical instruments and equipment, and reviewing the storage of suture material.

CASE REPORT #4

ZOONOTIC

FARM: 28 cows, stanchion barn, separate lots for heifers, bred heifers and dry cows, and lactating animals.

HISTORY: On March 22, an open heifer was examined for stiffness, trouble getting up and constipation. The owners had observed this animal in a very strong heat for the past 24 hours, and felt this could be part of her problem because of the excessive activity. On March 23, a bred heifer in a different lot was examined for CNS signs which included staggering and paresis. The evening of March 24, both animals died and a post mortem exam was performed on each. The brains were submitted to the Minnesota Department of Health. On March 27, a cow which had calved two weeks prior with problems was found to be off feed with a severe metritis and ketosis. On March 30, this cow also died and the brain was submitted.

FINDINGS: All three specimens were found rabies positive by fluorescent antibody microscopic examination.

DISCUSSION: In this case, the owners son recalled seeing a skunk in the yard during the day approximately two weeks prior. Minnesota has consistently ranked in the top five states in the U.S. for the number of animal rabies cases identified. The skunk accounted for 62 percent of the diagnosed cases and is the most important animal species for maintaining rabies in Minnesota. Cattle, dogs, cats and other species accounted for 18, 6, 5.5, and 8.5 percent, respectively, of the remaining reported animal rabies cases.

Rabies in humans is characterized by a variable incubation period (i.e., length of time from exposure to onset of clinical symptoms), usually between 3 and 8 weeks but varying from 10 days to 1 year. The Minnesota Department of Health reports that from 1907 to 1977, 18 human deaths were attributed to rabies in Minnesota. Sixteen of those deaths occurred prior to 1917, with only one rabies death reported in 1964, and one in 1975.

Although cattle account for the second highest number of diagnosed cases of rabies in Minnesota, swine and horses occasionally may be infected. This primarily is due to their close proximity to skunks and the increased exposure factor. It is neither considered economically feasible, nor is it justified from a public health standpoint to vaccinate all livestock against rabies. However, owners who have valuable animals located in areas where wildlife rabies is endemic are encouraged to have their animals vaccinated annually.[3]

No human rabies attributed to bovine have been reported in this country in many years; the last reported case occurred in California in 1938.

In Minnesota, rabies is not endemic in rodents (hamsters, gerbils, guinea pigs, chipmunks, squirrels, rats, mice, gophers, its), insectivores (moles and shrews) or lagomorphs (hares and rabbits). The Minnesota Department of Health (MDH) has not reported any animals of these species positive for rabies since 1960. The rare positives reported by the MDH in these species prior to 1961 most likely were laboratory false positives.

The Minnesota Department of Health discourages testing rodents, insectivores or lagomorphs for rabies unless aggressive behavior has been shown. Bites from these animals have never resulted in human rabies in the United States and exposure to these animals rarely, if ever, indicates the need for post-exposure rabies prophylaxis. However, treatment to prevent other types of infection (including tetanus immunization if indicated) should always be given.[4]

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CLINICAL CASE REPORTS

submitted by

Dr. Gary D. Neubauer
Nicollet-New Ulm Veterinary Clinic
New Ulm, MN. 56073

CASE REPORT #1

SYSTEMIC PROBLEM

FARM: 117 cows, parlor system with free stall housing and a rolling herd average of 16,800 and a SCC average of 220,000.

HISTORY: Problems on this farm started in Feb. 1989 when heifers freshened with non-responsive uterine infections, weight loss, and displaced abomasums. These problems continued through June with successive groups of freshening heifers. Early in July, both high and low milking groups broke with diarrhea of about one week duration. In July, two to four week old calves became ill with fever, listlessness, diarrhea, and dehydration.

MANAGEMENT: The dairy operation has expanded from 80 cows to 117 over the last 2 years, and continues to raise out all their steers. This is a total cemented system with 2 manure lagoons. There is a definite overcrowding and sanitation problem. The herd is bred with 2 different purchased bulls and some AI. The feeding program involves a TMR system. Calves are born in 2 maternity pens and then transferred to individual calf hutches in a converted machine shed. During the end of June and July, there were so many calvings (29) that one of the maternity pens was made into a group calf pen.

FINDINGS: The University of Minnesota diagnostic lab isolated salmonellosis from 3 calves and 2 heifers. The salmonella was identified as serotype 9.12: nonmotile and further identified as salmonella enteriditis by the Minnesota Department of Health. Further investigations by the University of Minnesota epidemiology department failed to identify the source of salmonella (fecals, manure pit, water, feed, and milk filters were all negative on culture).

DISCUSSION: Transmission among cows - after salmonella gained entry into the herd, other cows were likely infected through fecal-oral transmission. This could occur at several places in the free stall barn. Transmission to calves - this is likely to have occurred in two ways. First, the calves likely became infected in the maternity areas which are directly adjacent to the free stalls (including ill cows). Second, because of the heavy calvings in July, a maternity pen was converted to a group calf pen. These calves when later moved to hutches in the machinery shed probably carried salmonella with them. Also these calves were fed colostrum and raw milk for the first week which is a potential spread of salmonella. Public health risk - salmonella enteriditis is a zoonotic disease which can be spread through raw milk and the feces. Even though the family did drink raw milk and did help treat these sick animals - no one became ill, except for one of the veterinarians working on the case.

SUMMARY: We continued to search for the source of salmonella by culturing individual feed ingredients and then looked at the feed mixing area and other feed areas for possible contamination; unfortunately we have been unsuccessful. We encouraged reduction of herd size to reduce crowding in free stalls, overflow of manure pits, and overcrowding of maternity pens. Improvement of cow sanitation by reducing herd size, improving cows use of free stalls, improving fly control and twice daily scraping of alleys was instituted. Also, efforts were made to improve the cows immune status by supplementing vitamins A, D, E, and selenium during the dry period, along with boostering various vaccination programs. Finally, calf husbandry and sanitation were improved somewhat by clean maternity pens, avoiding overcrowding, ensuring adequate colostrum intake, and disinfecting calf hutches between uses.

DISCUSSION OF SALMONELLOSIS:

SOURCES: Potential sources of on-farm infections include rodents, birds, contaminated water, and pasture with the major sources being feedstuffs and infected carrier animals. Bone, meat, fish, and feather meal are often contaminated with Salmonella organisms. Although these products are heated and cooked during processing, they are often recontaminated after processing. These types of meals are conducive to dissemination of infectious organisms to a large population from a single source.

TREATMENTS: There is varying opinion among veterinary clinicians on how to treat clinical salmonellosis. It is agreed that oral or parenteral administration of fluids, electrolytes, and buffers is important to correct dehydration and balance electrolyte losses and acid-base abnormalities. Intestinal absorbents and protectants, such as activated charcoal and kaolin, may be helpful in some cases.

The use of antimicrobials in acute salmonellosis, however, is controversial. Antimicrobials do not eliminate the carrier state and may contribute to the development of antibiotic-resistant strains. Results tend to be poor if treatment is not administered until late in the disease; however, a high cure rate is obtained if the proper antimicrobial treatment is begun early.

CONTROL: Salmonella is difficult to control because of its ability to survive in the environment and because of animal carrier hosts. Salmonella is often found in water sources as a result of contamination. Potentially contaminated and stagnant water sources should be avoided and made inaccessible to animals. The use of fresh water free of organic material may reduce exposure to Salmonella, because it is unlikely that the organism can survive more than 3 weeks in such water, however, Salmonella may remain viable for up to 9 monthes in pond and stagnant water.

Management of manure should be directed to heating and drying, because Salmonella is sensitive to both of these processes. The bacterium, however, can remain viable on pasture in feces, and in the soil for up to 7 months. Freezing will decrease survival, but some organisms will be viable after thawing. Salmonella-contaminated concrete areas, metal waterers, and equipment should be cleaned and then disinfected with common phenolic, chlorine, or iodine-based disinfectants.

Because the stress of transport will cause an increase in shedding of organisms in carrier animals, newly transported animals should be quarrantined for 4 weeks after arrival to reduce the chance of exposure of organisms to resistant animals and contamination of the environment. 1

CASE REPORT #2

ENTERIC

FARM: 35 cows, tie stall barn with a 18,200 rolling herd average, calves raised in elevated calf stalls

HISTORY: In Feb. of this year several calves came down with a mild yellow diarrhea at 2-3 weeks of age. This progressed over a weeks time to a blood tinged diarrhea and subsequent death. Treatments included amproluim, corrective mixture, trimethorprim-sulfa, gentamicin, electrolytes and diaproof.

FINDINGS: Fecals and cultures were run for coccidiosis, cryptosporidiosis, and bacteria upon initial visit. Results from our in-house lab revealed a non-hemolytic E.coli and cryptosporidiosis. Upon further investigation, tissue samples were sent to the University of Minnesota diagnostic lab and the diagnosis came back, enteritis due to cryptosporidiosis and attaching and effacing E. coli infection.

DISCUSSION OF CRYPTOSPORIDIOSIS: An ever increasing enteric pathogen in dairy calves

TREATMENT: The most effective treatment is to avoid overuse of antimicrobial drugs. Keep calves warm, dry, and well fed. Expect a slow recovery in 5 to 10 days.

PREVENTION AND CONTROL: Resistant to most disinfectants. Freezing and thorough drying are the most effective. Pens, crates and utensils should be cleaned with a 5% ammonia solution and dried. Areas cleaned and frozen are probably free of infectious cryptosporidiosis. Adequate immunity through good, quality colostral intake is essential. Finally, human hygiene is very critical since cryptosporidiosis ia a zoonotic disease.

DISCUSSION OF ATTACHING AND EFFACING E. COLI: Attaching and effacing E coli should be considered an emerging new member of the calf diarrhea complex. Although not as common as the other major causes of diarrhea in young calves (enterotoxigenic E coli, rotavirus, coronavirus, cyrptosporidia), the organism appears to be widely distributed throughout the cattle population of the north central United States, especially in dairy operations. Whether this is a newly introduced or evolved disease or whether heightened awareness has led to increased recognition is uncertain.

Enterotoxigenic E coli infection such as K99 is exclusively a disease of the small intestine. In contrast, attaching and effacing E coli organisms were adherent in small and large intestine, most frequently in the colon. 2

While attaching and effacing E. coli sometimes occurs as a subclinical infection with very little bloody diarrhea, it is often fatal in calves 1-3 weeks old, especially when seen in conjunction with other enteric pathogens. Others believe that this E. coli may pose a human health hazard through unpasterized milk and undercooked meat. Finally, there may be a relationship between colostrum quality, the young animal's colostral intake, and the particular E. coli infection. Infection with attaching and effacing E. coli should be considered in young calves with hemmorrhagic colitis or when blood is observed in the feces.

CASE REPORT #3

SURGICAL

HISTORY: Adult bovine surgeries performed by the clinic last year included - left displaced abomasums=303, right displaced abomasums=33, c-sections=13, and exploratorys=58. The surgical protocol used included, clipping, surgical scrub using nolvasan, line block of area using lidocaine with epinephrine, drape the area, use of a rubber ob gown, surgical gloves, cold sterilization of equipment using benzall, and use of catgut and vetafil in sterile spools. Procaine penicillin both intraperitonelly and intramuscularly was administered and the incision line was medicated with topazone.

Post surgical complications tended to be very minimal or insignificant. However, starting in August of 1989, the formation of surgical granulomas along the incision line in several animals became evident. The surgeries on these animals were all LDA'S that had been performed four to six months prior. The incisions had healed routinely with no signs of problems, the hair had grown back with no visual signs of scarring or complications. Then approximately 4 months down the line the incision area started to swell and bulge. The swellings continued to increase until some broke open and formed proud flesh like lesions which we referred to as granulomas.

FINDINGS: Sections of these lesions, along with aerobic and anaerobic ciltures were submitted to the University of Minnesota diagnostic lab for identification. Results included isolation of Pseudonomas areugenosa.

DISCUSSION: Possible sources of contamination included, cold sterilization technique of the equipment, spools of suture material, surgical gown, and local anesthetic.

Changes which were instituted included, using lidocaine without epinephrine, autoclaving all surgical instruments and equipment, and reviewing the storage of suture material.

CASE REPORT #4

ZOONOTIC

FARM: 28 cows, stanchion barn, separate lots for heifers, bred heifers and dry cows, and lactating animals.

HISTORY: On March 22, an open heifer was examined for stiffness, trouble getting up and constipation. The owners had observed this animal in a very strong heat for the past 24 hours, and felt this could be part of her problem because of the excessive activity. On March 23, a bred heifer in a different lot was examined for CNS signs which included staggering and paresis. The evening of March 24 both animals died and a post mortem exam was performed on each. The brains were submitted to the Minnesota Dept. of Health. On March 27 a cow which had calved two weeks prior with problems was found to be off feed with a severe metritis and ketosis. On March 30 this cow also died and the brain was submitted.

FINDINGS: All three specimens were found rabies positive by flourescent antibody microscopic examination.

DISCUSSION: In this case, the owners son recalled seeing a skunk in the yard during the day approximately two weeks prior. Minnesota has consistently ranked in the top five state in the U.S. for number of animal rabies cases identified. The skunk accounted for 62 percent of the diagnosed cases and is the most important animal species for maintaining rabies in Minnesota. Cattle, dogs, cats, and other species accounted for 18, 6, 5.5, and 8.5 percent, respectively, of the remaining reported animal rabies cases.

Rabies in humans is characterized by a variable incubation period (i.e., length of time from exposure to onset of clinical symptoms), usually between 3 and 8 weeks but varying from 10 days to 1 year. The Minnesota Department of Health reports that from 1907 to 1977, 18 human deaths were attributed to rabies in Minnesota. Sixteen of those deaths occurred prior to 1917, with only one.rabies death reported in 1964, and one in 1975.

Although cattle account for the second highest number of diagnosed cases of rabies in Minnesota, swine and horses occasionally may be infected. This primarily is due to their close proximity to skunks and the increased exposure factor. It is neither considered economically feasible, nor is it justified from a public health standpoint to vaccinate all livestock against rabies. However, owners who have valuble animals located in areas where wildlife rabies is endemic are encouraged to have their animals vaccinated annually. 3

No human rabies attributed to bovines has been reported in this country in many years; the last reported case occurred in California in 1938.

In Minnesota rabies is not endemic in rodents (hamsters, gerbils, guinea pigs, chipmunks, squirrels, rats, mice, gophers, its.), insectivores (moles and shrews) or lagomorphs (hares and rabbits). The Minnesota Department of Health (MDH) has not reported any animals of these species positive for rabies since 1960. The rare positives reported by the MDH in these species prior to 1961 most likely were laboratory false positives.

The Minnesota Department of Health discourages testing rodents, insectivores or lagomorphs for rabies unless aggressive behavior has been shown. Bites from these animals have never resulted in human rabies in the United States and exposure to these animals rarely, <u>if ever</u>, indicates the need for post-exposure rabies prophylaxis. However, treatment to prevent other types of infection (including tetanus immunization if indicated) should always be given.4

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JOHNE'S DISEASE IN CATTLE: OVERVIEW AND UPDATE

Raymond W. Sweeney, VMD, Diplomate ACVIM (Int. Med.)
Robert H. Whitlock, DVM, PhD, Diplomate ACVIM (Int. Med.)

Paratuberculosis (Johne's disease) occurs worldwide and is widespread in the United States. A slaughter survey in cows from northeastern states estimated the prevalence of paratuberculosis in cull dairy cows at 7.3% and a similar survey in Wisconsin revealed a 10.8% prevalence.[1,2]

Economic losses due to paratuberculosis may include decreased milk production, premature culling, and increased susceptibility to other diseases.[3,4] In Pennsylvania alone, over 500 herds positive for Johne's disease have been identified with economic losses estimated at $5.8 million annually. Of the 10.8 million dairy cows in the U.S., nearly 1 million are thought to be affected, and the total losses due to paratuberculosis are expected to exceed $1.5 billion annually for the dairy industry in the United States.[2]

Diagnostic Tests

The most widely accepted diagnostic test for paratuberculosis is fecal culture for Mycobacterium paratuberculosis. The test is highly specific with no false-positive results if conducted properly. Disadvantages of this test include difficulty in specimen handling, 12 to 16 week incubation period, contamination of samples by molds and bacteria (especially in silage-fed animals) and lack of sensitivity (less than 50% of infected animals may be detected on a single test). Although the lack of sensitivity may be due to intermittent fecal shedding of M. paratuberculosis by infected animals, we believe that in most cases organisms are shed, but below the detection limit of the culture system, giving false-negative results. Improvements in the fecal culture technique have allowed improved detection of fewer organisms and thus, improved sensitivity. By centrifugation of the fecal suspension, organisms are concentrated into the pellet prior to re-suspension and inoculation onto Herrold's egg yolk medium slants. This technique alone has increased the sensitivity of the fecal culture test 200 to 300%[5]. When routine fecal samples are collected (for herd testing for paratuberculosis), split, and tested by both techniques (centrifugation versus traditional/sedimentation), there are 2 to 3 times as many positive cows detected with the centrifugation technique compared to the suspension method. These cows are most commonly asymptomatic, "light shedders" that will continue to shed few organisms but not be detected by the traditional fecal culture test for 1 to 2 years. Associated with the use of the centrifugation method is a slight increase in the bacterial and mold contamination rate (5 to 10%). A recent modification of the culture technique includes a double incubation step with antimicrobials added to culture medium which nearly eliminates contamination, permitting processing of a larger fecal sample (5 gm vs 2 gm) thus further enhancing sensitivity. Centrifugation with double incubation of a 5 gm sample should detect less than 10 CFU of organisms per gram of feces.

Despite the major improvements in the fecal culture testing technique, the major disadvantage remains the prolonged incubation period, and in some areas, limited laboratory capacity for handling a large number of samples. Therefore, more rapid serologic tests have been investigated. Currently, there is a commercially available agar gel immunodiffusion (AGID) test that is USDA licensed for use by veterinarians in some states (RJT [R], Immunocell). The AGID test has very poor sensitivity when used to screen asymptomatic animals in herds where the disease is prevalent; as few as 10% of infected animals may be detected. However, the test has good sensitivity (70 to 90%) and specificity (80 to 90%) when used in cows with clinical signs of Johne's disease, i.e., diarrhea and weight loss. Therefore, the positive- and negative- predictive value for AGID test results is quite poor when the test is applied to the population at large, and it is inappropriate to use this test to screen herd replacements or to make culling decisions for asymptomatic animals on the basis of this test. However, when presented with an individual cow with weight loss and/or diarrhea, and faced with a decision to treat or cull, the AGID test can provide information that will lead to the more rapid culling of clinical Johne's suspect animals.

The ELISA test has been an attractive alternative to the AGID since it may be automated to accommodate a large number of samples, and improved sensitivity compared to the AGID test is expected. ELISA testing is currently available only through a limited number of commercial and research laboratories. Unfortunately, the improved sensitivity achieved with the ELISA is accompanied by a reduction in specificity. Whereas one study reported a sensitivity of 70% and a specificity of 90%[6], others report sensitivity of 40 to 60% and specificity of 50 to 80%[7,8]. It is our opinion that, as is the case with the AGID test, ELISA testing as currently available should not be considered reliable for the screening of individual animals for paratuberculosis.

The most promising new development in the diagnosis of paratuberculosis is the DNA probe. Mycobacterial organisms in the test specimen are lysed to release DNA, and the double stranded DNA is cleaved. Enzyme- or radio-labeled DNA segments known to hybridize with M. paratuberculosis DNA are added, and the labeled, hybridized segments detected. Using Polymerase Chain Reaction technology, a small number of DNA segments in the test specimen can be reproduced many-fold, increasing the sensitivity of the test. Initial indications are that the DNA probe applied to fecal specimens will have sensitivity and specificity equal to the fecal culture without centrifugation. The major advantage of the DNA probe is the rapidity (36-48 hours), the elimination of the need for viable organisms that will grow in culture and the elimination of sample decontamination procedures. Due to equipment required to conduct the test (thermal cycler), the DNA probe in its current form will only be available in commercial or research laboratories.

Transmission

It is commonly recognized that M. paratuberculosis is transmitted to young calves by oral ingestion of organisms from feces of infected cows, often by suckling a manure-contaminated udder. However, alternative mechanisms have been recognized: we have investigated the trans-placental transmission of paratuberculosis and the possible direct shedding of M. paratuberculosis into the milk of infected cows.

The possibility of transplacental transmission of paratuberculosis has been recognized since 1929, when Alexejeff-Goloff reported isolation of M. paratuberculosis from the fetus of a cow with clinical signs of Johne's disease. More recent reports have confirmed that 25 to 30% of fetuses from cows with symptomatic Johne's disease are infected in utero[9,10]. However, our studies involving asymptomatic cows (which comprise the majority of infected cattle) showed a much lower prevalence (5%) of uterine infection in this group. Transplacental transmission in asymptomatic cows would appear to be restricted to the "heavy shedders".

Alexejeff-Goloff reported the isolation of M. paratuberculosis from milk in 3 of 4 cows symptomatic with Johne's disease in 1935, and reports since then have shown up to 35% of symptomatic cows had organism detected in the milk[11,12]. However, our work shows that 10% of asymptomatic cows have the organism detected in milk, with the likelihood of detection greater in the "heavy shedders". We do not currently recommend the pasteurization of milk or colostrum from all cows on endemic farms, but milk from known culture-positive cows (especially clinically affected cows) should not be used to feed calves.

Eradication -- Case Experience

A heavy infected Guernsey herd was identified in 1983. Of 42 adult cows sampled on the initial test, 16 were positive (36%). An additional 13 of the original 42 were identified as culture-positive on subsequent tests over the next 5 years. Strict control procedures were instituted including immediate removal of newborn calves from dam and bottle feeding of colostrum, housing of heifers in a newly-constructed barn physically separated from the adults, and immediate culling of fecal culture-positive animals. Of 159 home raised replacements cultured repeatedly for paratuberculosis from 1983 to 1989, 45 (28%) were positive but with a decreasing prevalence over time. All animals were culture negative on the most recent test. Of the calves born to positive cows before the management changes, 65% were subsequently positive, whereas only 17% of the calves born to positive cows after the management changes were subsequently positive. Of the calves born to negative cows, 54% eventually were positive if born before the changes, 4% after the changes. Seemingly, these management changes were effective in limiting transmission. This case history emphasizes that even with stringent control procedures, a minimum of 5 to 8 years will be required to eliminate the disease from a herd.

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A New Problem Solving Premilking Cow Preparation Method

J.K. Reneau, R.J. Farnsworth and D.G. Johnson
University of Minnesota

It has been demonstrated in Minnesota field studies that 80% of herds experiencing either high somatic cell counts or high levels of mastitis do not follow recommended milking procedures. Teats are usually inadequately sanitized and dried prior to machine application. Compelled by speed of premilking preparation rather than thoroughness, milkers often fail to achieve a good milk letdown stimulus especially in late lactation cows. In herds where there is more than one milker, there is usually a great variation between milking routines. All of these factors contribute to poor milk quality and udder health as well as inefficient milking.

The ideal premilking cow preparation should:

1) Reduce the excess use of water.
2) Increase the milker's ability to accurately target the teat with the wash solution.
3) Use a sanitizer in a concentration that results in the quick kill of bacteria but does not adulterate milk.
4) Provide adequate contact time for teat disinfection.
5) Result in a sufficient milk letdown stimulation (15 to 20 seconds).
6) Remove all the organic matter form teat surfaces.
7) Minimize the variability in the milking routine between milkers.
8) Not slow down milking.

If a premilking sanitation procedure can be developed which can be practically applied on dairies, it is anticipated that great advances can be made in milk quality, udder health and milking efficiency.

There is a direct linear relationship between the degree of bacterial contamination of udder and teat surface, and milk quality and udder health (4). Recent research (1) has clearly established that good washing and drying with separate paper or cloth towels will reduce teat surface bacterial population 75%. Using udder sanitizers at current recommended concentration only resulted in a 5% improvement over use of udder wash solutions without sanitizers (5, 10).

The use of "predipping" in a Cornell study shows that predipping plus drying reduced infection rate by environmental pathogens 63% compared to 43% for washing with a wet towel and drying (2). Vermont predip studies show a decreased infection rate by environmental pathogens of 51% in field studies (7).

Misinterpretation of the predip studies in the upper midwest has led to improper use of the predipping procedure. Teats need to be visibly clean and free of organic debris prior to predip application for consistent results. But if the farmer does comply to a proper predip procedure, which in most upper midwestern dairies requires washing teats prior to predip application, additional time is spent milking. There is concern among dairy farmers about adding time to the milking routine. The average time spent in premilking cow preparation (forestrip, wash, dry) in Minnesota herds is approximately 7 to 10 seconds. The recommendation to spend a minimum of 15 to 20 seconds in washing, forestripping and drying each cow to achieve both good teat sanitation and milk letdown is met with resistance. Yet, controlled research studies show that smoothness in milking routine, milk quality, as well as udder health, are all benefited by thorough premilking sanitation (9).

English studies have shown that the use of wash solutions with sanitizers in higher than normally used udder wash concentrations (.6 Hypochlorite) achieved excellent teat sanitation when applied by milkers in a prescribed standard teat cleaning procedure (3). This article reports the results of a University of Minnesota study comparing typical parlor and stall barn milking procedures to a very standardized premilking cow preparation procedure using a low pressure teat spray system and a predip as a wash solution. The purpose of this study was: 1) to test the adaptability to upper midwestern dairies of the spray equipment and the standardized predip teat wash procedure; 2) to test the effectiveness of the predip wash procedure in reducing the bacterial population on the teat compared to traditional teat wash preparation and where there is no preparation (dry wipe); and 3) to test the effect of the standardized cow preparation procedure on milking time and milker's behavior.

Materials and Methods

Description of dairy herds. Two herds were used in this study. A 600-cow free stall herd with a double-8 automatic take-off parlor, and a traditional 60-cow tie stall herd with a pipeline milking system. The 600-cow herd was housed in a slotted floor free stall facility separated into 4 lactation groups. The stalls were 4' x 7' cement with rubber mats bedded with kiln-dried wood shavings. Chopped straw bedding was used in the 60-cow tie stall herd.

Premilking methods. Three premilking cow preparation methods were compared: 1) no preparation in which the milking machine was applied with no attempt to do more than dry wipe by hand the gross organic material off prior to machine application; 2) traditional cow preparation procedure in which the parlor herd milkers used a plain water hand wash with drop hose method, and the tie stall herd which used a wash bucket with udder sanitizer and separate paper towel wash method; and 3) the experimental predip/wash system in which milkers were trained to do a very specific predip/wash method.

Milkers were instructed to prepare cows using the traditional cow preparation procedure as they were always accustomed to doing previously. However, prior to the beginning of the experiment each milker was trained in the experimental predip/ wash method. The experimental predip teat procedure was conducted as follows: using the low pressure teat spray unit[1], each teat was simultaneously sprayed with Lauricare[2] and washed by 3 or 4 vertical motions of the hand, then using the thumb and first finger in 1 to 2 horizontal motions across the teat end to remove dirt and manure from the teat end. Prior to moving to the next teat, forestripping was done

[1]Teat Power Sprayer or hand held trigger sprayer, RJB Co., Modesto, CA.

[2]Lauricare teat dip, 3M, St. Paul, MN.

to check for clinical mastitis. This entire process should take approximately 3 to 5 seconds per teat (depending on udder cleanliness) or a minimum of 15 to 20 seconds per cow. This provides adequate stimulation for consistent good milk letdown in most cows, and better assures both removal of organic matter from the teat surface and good coverage of the teat dip. A minimum of 30 seconds of contact time was allowed for the disinfectant to kill the bacteria. The teats were then dried using a single service towel (cloth-parlor herd, paper-tie stall herd) and milking units applied.

Milk sample collection. Bacterial contamination of teat surfaces was indirectly measured by bacterial culture of aseptically collected individual cow composite milk samples. Surge TruTest DHI milk test meters were adapted to aseptically collect milk samples proportionate to the milk production of each cow sampled. At the completion of milking, the milk samples were mixed in the meter collection reservoir. Two ml/10 lb of milk produced was aseptically drawn via a sterile needle into a 12 cc plastic syringe. The samples were immediately frozen and stored for later bacterial culture analysis.

Bedding sample collection. **Parlor herd:** Random bedding samples were collected daily from the posterior one-half of each 3rd stall in each lactating group. These individual stall bedding samples were pooled by group and day of collection, and frozen for assessment of the average potential for teat contamination. Records were kept on the time and date of bedding change to aid in interpretation of bedding culture results and enable correlation with teat contamination.

Tie stall herd: Bedding samples were taken from the posterior one-half of each stall each day prior to milking. These samples, as in the parlor herd trial, were pooled by treatment group and day collected, and cultured to measure teat contamination potential in the stall barn.

Experimental design. **Parlor herd:** On sample collection day the adapted TruTest meters were fitted to three designated parlor stalls: one to collect milk sample from cows in which no cow preparation was done; one to collect those prepared by the traditional plain drop water hose plus hand premilking procedure; and one to collect those prepared by the predip teat wash test procedure.

To assure a more representative sample was taken by avoiding the bias of habitual cow entry into the parlor, premilking cow preparation methods were alternately shifted from one side of the parlor to the other on each sampling day. All of the 433 individual milk samples were immediately frozen. Individual samples were pooled for each lactation group, by day, and by treatment. Bulk tank cultures (6) were run on a sub-sample from each of the pooled samples for each sample day. Samples were collected daily on 5 consecutive days. Additional detailed measurements were made to compare cow throughput, teat dip use, and milking routine between treatments and milkers.

The week prior to the 5-day collection period all cows were prepared for milking using the drop hose and water method. The week following the collection period all cows were prepared for milking by the predip wash preparation method.

Bulk tank milk samples from the entire herd were collected for the week prior to and following the 5-day collection period. A bulk tank microbiological comparison was made relative to the potential for teat contamination from bedding and the ability of the two premilking cow preparation methods to remove bacteria from the teats.

Tie stall herd: This trial was a latin square design in which every cow received each treatment for two collection days. The herd was split into two groups; thus, replicating the experiment twice in order to strengthen statistical inference. Milk samples were taken very similar to the parlor herd trial via the adapted TruTest meter.

Time and motion studies of milking procedure were completed in order to compare the effects of each premilking cow preparation procedure on milking routines.

Summary of Results

Effect on milking time. Milkers on most Minnesota dairies average 7 to 10 seconds time in premilking cow preparation (forestrip, wash, dry). In most cases even doubling premilking cow preparation will not add significant time to the overall milking time. In this study increasing premilk cow preparation time by 150% did not have a significant effect on parlor throughput (Table 1). To milk 534 cows using the prescribed predip/wash method added 29 minutes to each milking. Increasing cow preparation time in late lactation cows appeared to speed parlor throughput.

Effect on milkers. The most change a cow should ideally experience in her daily life is a change in fresh feed at the feed bunk or a change of stall bedding. Routine is the key to high cow productivity. The fewer changes in a cow's daily routine, the better. This is especially true with regard to milking routine. Standardizing milking routine so that every cow is treated as closely the same at every milking during her lactation will improve milking efficiency and cow productivity. Recent research in Denmark demonstrates a 5% increase in milk yield where milking routine is standardized (8). The experimental predip/wash procedure did have a significant effect on increasing premilking cow preparation time and establishing consistency of milking routine between different milkers (Figure 1). Although there was not significant change, the experimental wash procedure did appear to result in less unit-on time and higher milk flow rates (Table 2). These observations of improved milking efficiency in response to longer premilking cow preparation have been observed in other studies (9).

Effect on teat sanitation. The experimental predip/wash procedure resulted in a highly significant reduction of teat surface bacterial contamination compared to no wash (dry wipe). When teat contamination was high and premilking teat wash routine average, there was no statistical difference between no wash and the standard drop hose plain water method. But there was a highly significant difference between no wash premilking cow preparation and the experimental predip/ wash method. However, when teat contamination was moderate to low or when the premilking cow preparation excellent, there was no significant difference between the standard wash procedures and the predip/wash method (Table 3, Figure 2).

An interesting exception was milker #4 (Figure 2). This milker did not follow the experimental protocol. Premilking cow preparation time for both the standard crop hose method or the experimental predip/wash method was a total of 7 seconds. In this case there was no significant difference in teat surface bacterial contamination between the no wash and either the standard drop hose plain water wash or the experimental predip/wash (Figure 2). This observation may help to explain the inconsistent and often ineffective results seen in using predipping where there is improper application of the technique.

The tie stall barn trial results show trends similar to the parlor herd study (Figure 3, Table 3. There was a highly significant reduction in teat surface bacteria by both premilking cow preparation procedures compared to the no wash procedure. However, the experimental predip/wash cow preparation was not significantly more effective in reducing teat surface bacterial contamination. Again demonstrating the point that if premilking cow preparation is excellent it is not anticipated that predipping, or the predip wash method used in this study, will be superior in lowering bacterial contamination on teat surfaces.

Another point can be made from the tie stall trial data. This trial was conducted in August 1989 during some very hot and humid weather. The cows in this herd were bedded daily and visually the udders were clean and free of organic debris. Yet the total bacteria (CFU/ml) as indirectly reflected by the no wash procedure indicates that there were considerable numbers of bacteria contaminating the teat surfaces (Table 3, Figure 3). Since it is desirable from the standpoint of milk quality to keep bacteria levels in milk below 5000 CFU/ml, it would seem inappropriate to recommend any no wash premilking cow preparation procedure on upper midwestern dairies.

Effect on milk quality. It is logical to expect that the result of lowering bacterial contamination on teat surface will in turn result in higher quality milk. Although the experimental design in this study did not allow clear cut proof, the data is supportive of that logic. Table 4 shows the bulk tank bacteriology when the entire herd's premilking cow preparation was only the standard drop hose plain water wash as compared to the entire herd being milked using the predip/wash method. Where average stall bedding contamination is nearly the same, the predip wash method reduces non-ag Streps tenfold and coag-negative Staphs onefold.

Conclusions

The predip wash premilking cow preparation procedure is an effective way to achieve nearly ideal premilking cow preparation. The procedure is objective in nature facilitating easy milker training and evaluation. It appears that good results could be expected in its application in problem mastitis herds where premilking cow preparation is known to be average to less than average.

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Table 1. Effect of cow prep method on milking parlor throughput: free stall trial.

	Average production (lb)	Average DIM	Drop hose & water Cow/hr	Experimental predip/wash Cow/hr
Herd	55		73	71
Group I	75	65	65	62
Group II	62	132	68	65
Group III	45	184	82	80
Group IV	27	265	90	91

Table 2. Effect of cow premilking preparation method on milking routine and milk production: tie stall herd trial.

	No wash	Paper towel + sanitizer + dry	Experimental predip/wash
Total prep time (sec.)	12	16	24
Prep-lag time (min. & sec.)	0:49	1:05	1:34
Unit-on time (min. & sec.)	5:20	5:13	5:06
Milk weight/milking (lbs)	20.7	21.2	21.7
Milk flow rate (lbs/min.)	4.0	4.2	4.3

Table 3. Effect of premilking wash method on milk bacterial count in a tie stall barn.

	No wash	Paper towel with sanitizer	Experimental predip/wash*
		CFU/ml	
Total bacteria	5592	2719	1233
Non-Ag Strep.	2034	596	647
Coliforms	2587	8	27
Staph. species	758	303	279
Staph. aureus	143	183	272

*Lauricare 3M (Active ingredients: 1% Laracidin, 5% caprylic acid, 6% lactic acid).

Table 4. Effect of pre-milking cow preparation method on herd bulk tank bacteria levels: free stall herd trial.

	Average bedding contamination	Bulk tank non-ag Streps	Coag neg Staph	Coli
Pre-trial week (entire herd prepped with drop hose & water method)	7.775×10^8/gm	>2000	400	0
Post-trial week (entire herd prepped with experimental method)	1.023×10^9/gm	253	200	20

Figure 1. Comparison of Premilking Cow Prep Method and Milker on Cow Prep Time

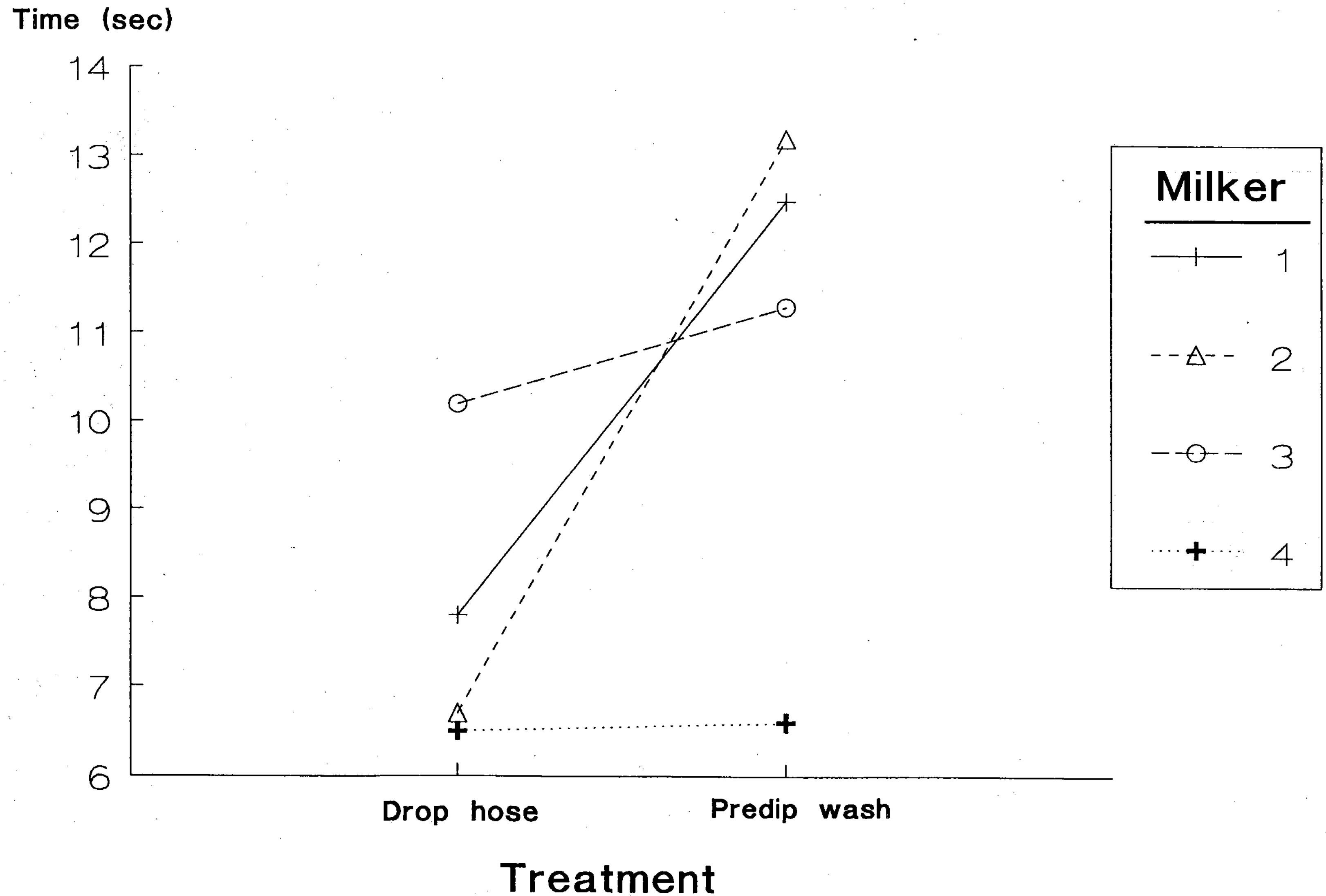


Figure 2. Comparison of Cow Prep Method and Milker on Bacterial Contamination of Teat Surfaces in a Free Stall Herd

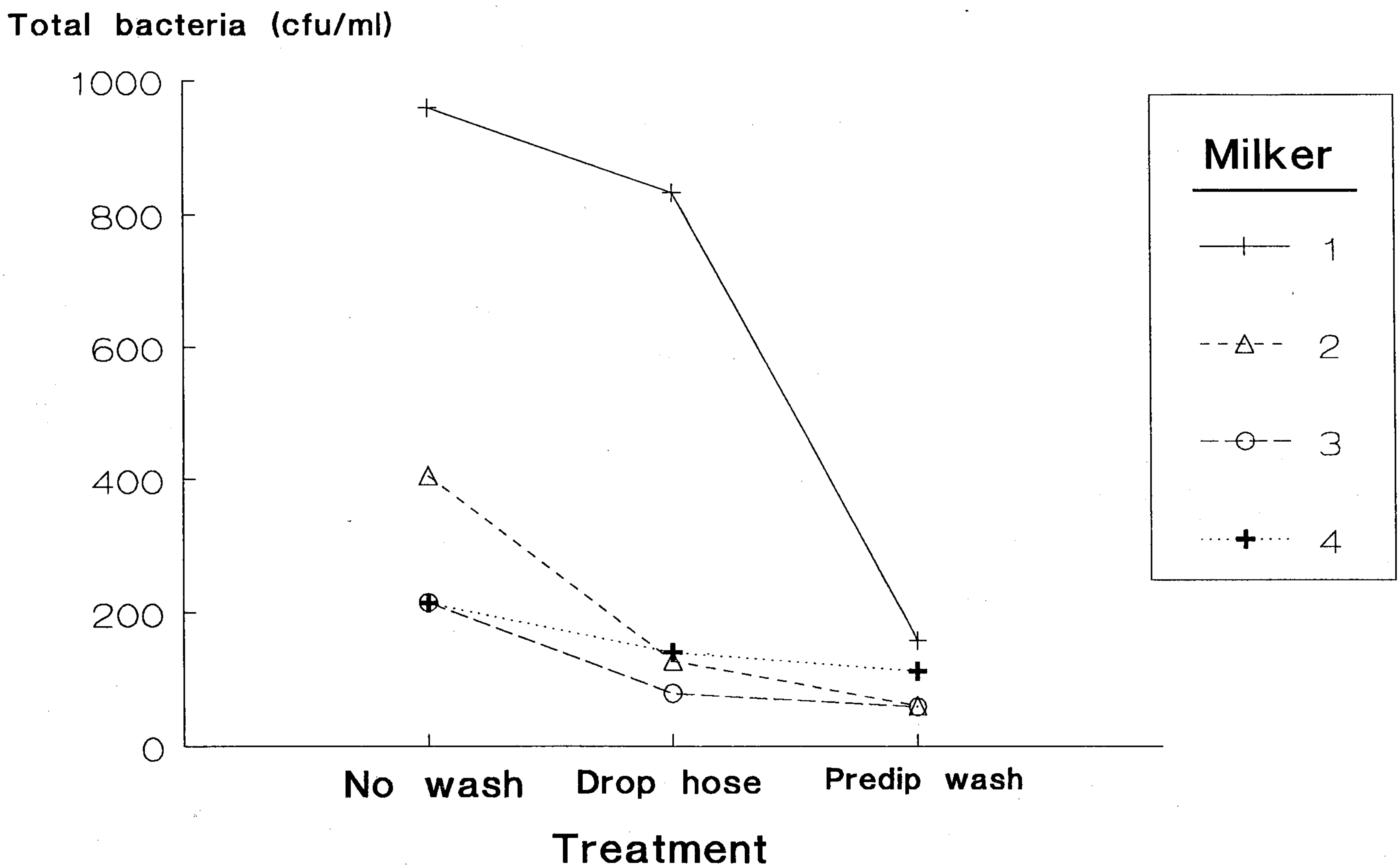
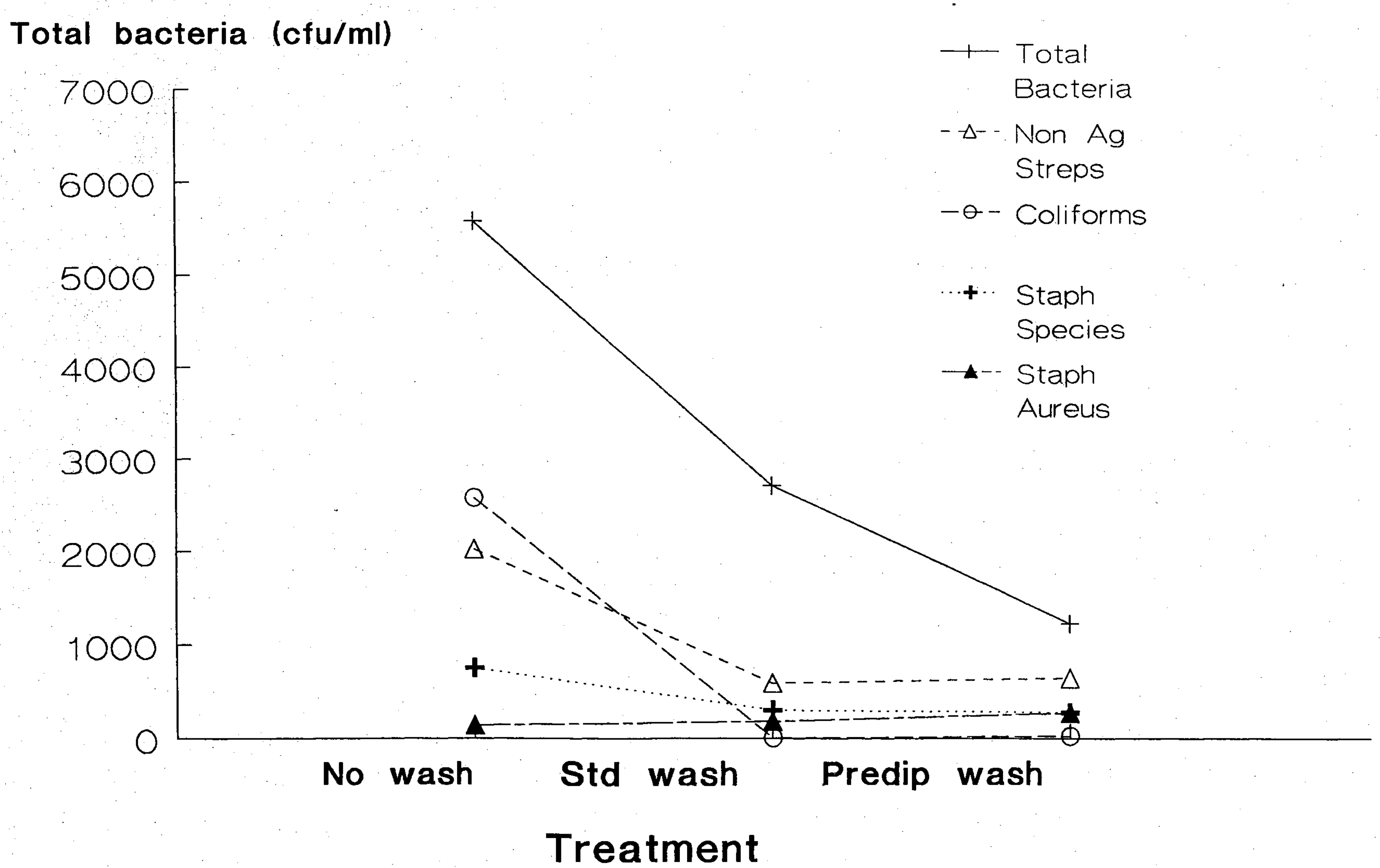


Figure 3. Effect of Cow Prep Method on Bacterial Contamination of Teat Surfaces: Tie Stall Herd Trial



Ultrasound and Bovine Reproduction

Harry Momont, DVM, PhD
Diplomate, American College of Theriogenologists
University of Minnesota
College of Veterinary Medicine

Since the 1950's, ultrasound has been used for routine medical diagnosis. Echocardiography is an example of this early use. By the late 1960's, ultrasound was being applied to cattle, primarily to measure carcass quality, but also as a pregnancy diagnosis tool. Early efforts focused on abdominal A-mode sonography, essentially the same technique used for trans-abdominal pregnancy diagnosis in swine. This method yielded an unacceptably high level of false-positive diagnoses. Doppler was being used for pregnancy diagnosis in cattle and small ruminants by the late 1970's. In the last decade, the clinical use of ultrasonography in large animal theriogenology practice has become commonplace. This is largely the result of the development of two-dimensional, real-time systems and their application in management of equine reproduction. These systems are either sector scan or linear array and use an intra-rectal probe.

Linear array has proven more popular for trans-rectal work because the image has the same width in the near-field, unlike sector systems that fan out to give a pie-shaped image with the widest portion of the image being furthest from the probe. The result is better resolution with linear array of objects very close to the probe, which is usually the case with trans-rectal ultrasonography. The resolution of the image on the screen is primarily dictated by the frequency of the ultrasound waves employed. Low frequency probes (3.0 to 3.5 MHz) can not resolve very small structures but will penetrate deeper into tissue so that larger objects, such as an advanced pregnancy, can be seen. They are more capable of penetrating the abdominal wall and are useful for transabdominal pregnancy diagnosis in small ruminants. High frequency probes (5.0 to 7.5 MHz) are capable of resolving very small structures and are excellent for trans-rectal diagnosis of ovarian structures or early pregnancy. If early pregnancy diagnosis in cattle or horses is the objective, a high frequency probe should be purchased.

Detection of pregnancy by visualization of the embryo proper is possible as early as day 20 in heifers (1), but may be more accurate at 22-24 days. Diagnosis of pregnancy is possible at about this same time in cows, however, accuracy decreases with increasing age of the cow (2) and later diagnosis is advised in pluriparous animals. Confirmation of a viable fetus can be made as soon as the fetal heart-beat is detected. This is generally possible between 25 and 30 days of gestation.

Real-time ultrasonography produces a 2-dimensional image of the tissue beyond the probe. Since fetal sex is grossly visible very early in gestation, ultrasound can reveal the sex of the fetus if the proper view can be obtained. Differentiation of male and female fetuses is based on location of the vulva, scrotum, and prepuce in relation to the tail, hind legs, and umbilicus. High frequency probes can accurately determine fetal sex between 60 and 80 days of gestation (3) and lower frequency probes between 70 and 120 days (4).

The safety of ultrasound technology has already been established for human and equine pregnancies. Pregnancy diagnosis with trans-rectal, real-time (B-mode) ultrasonography is likely to replace rectal palpation as the standard for safety and accuracy against which other diagnostic methods are measured in experimental trials. Concerns about uterine manipulation or palpation of the amniotic vesicle or the chorioallantoic membranes will become academic as the uterus can be viewed without manipulating it. It should be noted that bovine uterine anatomy is different from that of the mare, and very early pregnancy diagnosis may on occasion require manipulation or retraction of the uterus to assure that the entire uterine lumen has been examined.

Concerns about rectal transmission of disease are still valid because feces, and possibly blood, can be transmitted from cow-to-cow by use of a common sleeve and an unprotected ultrasound probe (see Rectal Palpation: Safety Issues in these proceedings). This problem can be addressed by covering the probe and the operator's hand in a new sleeve every time a cow is examined.

Ultrasound is not poised to replace rectal palpation as the primary means of pregnancy diagnosis in cattle in the near future. It does, however, have a lot to offer food animal veterinarians in terms of differential diagnosis of reproductive disorders (eg, follicular vs luteal cysts, follicular cysts vs normal corpus luteum, pyometra vs pregnancy) and it can make earlier diagnosis of pregnancy possible where it is economically justified. There are a few hurdles to overcome, however. First is the issue of cost. At $10,000 or more, most bovine practitioners find the equipment to be prohibitively expensive. Second is the issue of portability. While several units are small enough to be carried, none are portable enough to be easily carried from cow-to-cow. Battery power is also essential so that trailing cords are eliminated.

In addition, the advantage of methods that push back the limits of pregnancy diagnosis to earlier gestational ages must be weighed against the reality of fetal loss in the cow. The majority of fetal loss occurs between days 8 and 19 after breeding (5) but fetal loss is a significant problem until at least 40 to 50 days of gestation. Any veterinarian who conducts pregnancy diagnosis before this time must deal with the likely frustration of spontaneous fetal loss and the potential for this to be perceived by the client as diagnostic inaccuracy or, worse, the direct result of the examiner's technique.

Once the limitations of ultrasound are overcome, bovine practitioners are likely to embrace this new technology for use as an aid in pregnancy diagnosis as well as for other aspects of reproductive and general practice. Most practitioners will find ultrasound to be more time consuming than rectal palpation and, because of this, it is not likely to be used for routine rectal diagnosis unless it can be clearly shown that it is safer for the pregnancy than rectal palpation. Until then, rectal palpation will remain the standard for veterinary diagnosis of pregnancy in cattle.

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