Industry Presentation

Procedures and Products Required for Milking Center Efficiency, Mastitis Control, and Production of High Quality Milk

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Operating a dairy milking center involves managing a number of issues so that a satisfactory end result is accomplished. It involves labor management, work routine organization, mastitis control, cow physiology, Grade A milk production regulations, and agricultural economics. The involved parties may have different views of *objectives and satisfactory results,* so that has to be discussed and agreed upon. Once determined, the overall effort of running the milking operation must be aimed at meeting those objectives. The objectives need to be communicated to all involved from shift managers to milkers so that everyone knows the procedures and goals.

The following list includes typical milking operation objectives:

- The herd must be milked two or three times during a 24-hour period and the system washed and sanitized after each milking. This can become difficult when milking system capacity is pushed to the limit.
- Certain number of cows milked per hour or parlor turns per hour typically are goals. Accomplishing this requires a good understanding of the factors influencing it.
- Cows milked and pounds of milk harvested per man per hour may be goals.
- Producing good quality milk with acceptable somatic cell and bacteria counts. Managers should understand and accept the research data that has established the relationship between milk somatic cell counts, milk yield/cow, and clinical mastitis incidence rate. Milking center procedures and choice of udder health products should be aimed at helping meet the goals set for these parameters.
- Harvested milk must not contain any violative substances. On this issue there is no choice. Either milk is free of violative substances or it's dumped, either at the farm or at the plant. Evidence suggests that milk dumped due to antibiotic contamination is more likely to occur with herds experiencing high cell counts and excessive clinical mastitis. Therefore, procedures and products should be utilized that help minimize these issues.

During the planning phase the operating conditions and performance expectations for the milking center must be accurately described. Once operational, the performance and the interrelationships amongst all issues must be evaluated constantly to maintain an acceptable balance.

Questions to Consider When Planning a Milking Center

Will the herd be milked twice or three times daily? Will fresh cows be

milked more frequently? Are more cows planned for as time progresses and will the system, as built today, allow more cows to be added and still get the job done? Will sick pen cows and fresh cows be milked through the main parlor? Has a specific milking routine been developed, written, and posted for all to see? Will it involve forestripping, pre-dipping etc? Each of these decisions becomes critical, because each task involves time and if the time required exceeds the time available then the performance will be disappointing.

Who trains milkers on milking procedures and how is milking performance monitored? Much research has been conducted regarding various milking procedures and routines in herringbone, parallel, and rotary parlors. Decisions regarding milking routines etc. need to be made, as much as possible, based on facts that have been well documented by this research. Much of the focus of milking center performance research has been on factors influencing cows milked per hour and the return on investment. This focus may underestimate the impact of such decisions on clinical mastitis incidence rate and somatic cell counts. The difficulty has always been accurately quantifying these relationships.

For any capital investment the more efficiently and fully it can be utilized, the better return it produces. For a milking center it means the equipment needs to be used as efficiently as possible (efficiently defined as cows milked per man-hour of labor) and be as fully utilized as possible (hours per day in use).

There frequently is a conflict between cows milked per hour and cows milked per man-hour. There is a realistic limit of how much labor can be put in a parlor. Extra labor may increase cows milked per hour, but the labor cost per 100 pounds of milk produced may be unacceptable. Excess as well as insufficient labor may result in milking procedure inconsistencies.

Factors outside the milking facility can significantly influence parlor efficiency, udder health, and milk quality. Cows that enter the system with heavily soiled udders are an example of an external factor influencing all measures of milking center performance as well as milk quality and mastitis.

Assuming that more cows per hour can be milked with no problems when certain pre-milking procedures are dropped or minimized will not hold true if cows come in dirty and wet and the situation cannot be improved. These conditions force milkers to spend more time cleaning cows and implementing a more complete pre-milking routine in order to minimize the impact of these issues on mastitis and milk quality. Throughput will decline under these circumstances.

Regulatory Considerations

These are easy to overlook but must be considered when evaluating procedures. Certain FDA regulations determine what can or must be done at milking time. The Pasteurized Milk Ordinance (**PMO**) is primarily a public health document aimed at assuring Grade A milk poses no human health risk (US FDA, 2003). It states in item 1r that at the time of milking any milk observed to be abnormal needs to be discarded. How do you determine milk is abnormal? The most obvious way is to remove a few squirts and look at it. From a milk safety standpoint, observation of foremilk is expected.

Forestripping - Pros and Cons

From a mastitis control standpoint is foremilk examination a good tool to detect mastitis or high cell count milk? Is it worth the time? Yes and no. It has been estimated that 12,000 quarters have to be foremilked to find one new case of clinical mastitis based on normal rates (3 % per month) of new clinical mastitis infections. That's a lot of work to find one new case of mastitis. Foremilk removal and examination is still the best technique available today to help detect abnormal milk associated with clinical mastitis and prevent such milk going into the tank. On the other hand visual examination of foremilk often misses relatively high cell count milk that appears normal.

The next point involves whether or not forestripping produces a better, more complete letdown as well as faster and more complete milkout than milking procedures involving no forestripping. In the scientific literature, definitive research answering this question is either lacking or applies to a narrowly defined set of conditions. It is a measurement that has significant variation associated with parity, stage of lactation, degree of udder fill, frequency of milking, breed of cow, other pre-milking stimuli, etc.; which has to be accounted for somehow.

New Zealand milking procedures typically involve no pre-milking teat preparation, simply cups on! Their regulatory cell count limit is 400,000/ml and their national herd average is consistently well below this. Their bacteria counts are acceptable as well. Their industry involves different cows, pasture based housing and feeding system, different production levels, different milking systems, and very concentrated calving pattern; but that is how they do it. The end result likely is slow letdown cows become beef.

Foremilking takes approximately 6-8 seconds per cow and is difficult work. Is the time necessary and justified? Do US Holsteins require foremilking to produce a fast, full letdown and rapid, complete milkout?

Reneau and Chastain (1995) have indicated pre-milking procedures incorporating foremilking helped increase peak and average milk flow rates and reduced total machine on time. Wagner and Ruegg (2005) indicated that incorporating foremilking into a pre-milking routine that included pre-dipping, teat massage, and wiping produced no significant difference for milkout time, milk flow rates, and milk yield. They qualified their conclusions by stating they applied only to multiparous animals, since they had no first lactation animals in the study. The high producing group in this study also had significantly higher daily yields than cows used in other pre-milking stimulation studies and that likely had an impact on results.

Rasmussen et al. (1992) determined that the optimum interval between teat preparation and unit attachment was approximately 1.3 minutes. There was variation associated with breed of cattle and stage of lactation. Cows later in lactation benefited more from longer, more vigorous teat preparation than did early lactation cows.

Weiss and Bruckmaeir (2005) in Germany provided additional information. They looked at three groups of cows (early lactation, mid lactation, and late lactation). They categorized cows by udder fill as full,

medium, or limited. They exposed all cows in each group to three different milking machine induced pre-milking teat stimulation patterns exerted by rapidly opening and closing of the liner at reduced vacuum levels. The teats were not exposed to standard milking vacuum and pulsation during this pre-stimulation period. After the treatment was applied the system switched to normal vacuum and pulsation. One treatment involved no machine stimulation, simply the teat cups were attached and teats exposed to milking vacuum and pulsation.

In all studies there was no manual foremilking, udder washing etc. prior to machine attachment, so these tactile stimuli were not part of the pre-milking routine.

All cows had similar blood levels of oxytocin prior to stimulation. All cows, regardless of pre-milking treatment, had very similar oxytocin release profiles. Approximately 60 seconds after attachment of teat cups and application of the pre-stimulation program, oxytocin release occurred. In the case of the no pre-stimulation treatment the oxytocin release occurred approximately 60 seconds after machine attachment, but the level of oxytocin released and the duration and pattern of the release was no different than other treatment groups.

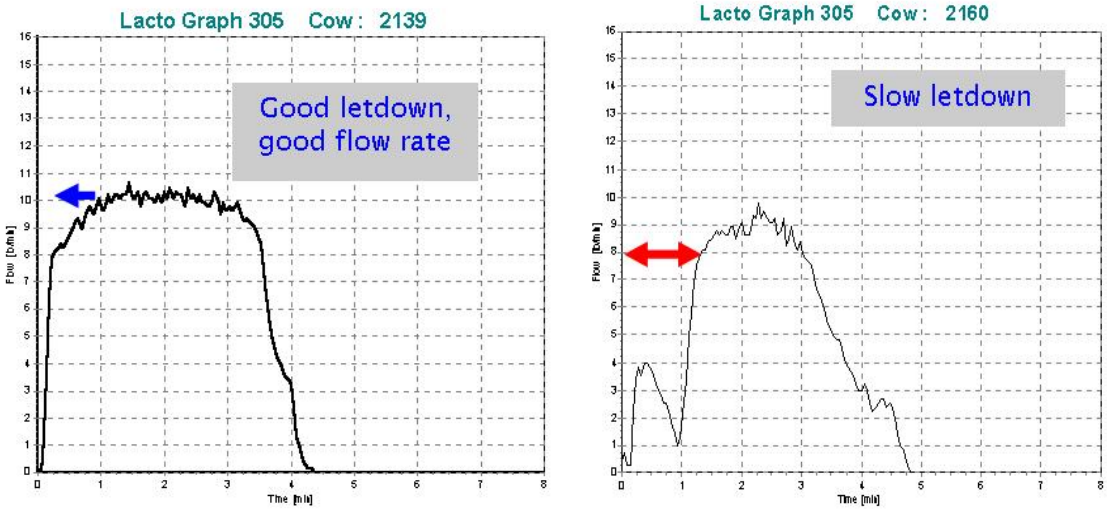
This research indicated that during early lactation and especially for cows with good udder fill, 15-20 seconds of teat stimulation is sufficient for initiation of full letdown. If no pre-milking teat stimulation is provided and units are simply attached, the action of the liner will lead to oxytocin release, but roughly 60 seconds after machine attachment. This would mean the possibility of a bi-modal milk letdown, which is occasionally seen on US dairies. These studies did not evaluate any manual teat stimulation routines however.

So What Are Appropriate or Required Pre-Milking Tasks?

For most US Holsteins, especially during the first half or more of lactation, full letdown is accomplished with approximately 20 seconds of teat end stimulation. The interval from application of the pre-milking stimulation until full oxytocin release and letdown is approximately 60-90 seconds. Teat wiping, teat pre-dipping, and rubbing the pre-dip onto the teat ends that amount to 15-20 seconds of teat contact will induce a full letdown within about 60-90 seconds. Incorporating forestripping may not improve letdown significantly, especially for early lactation high producing cows.

The reason is straightforward. The dairy cow's udder involves a two part storage system. Cisternal milk (20 - 30 % of total milk) in the teat and udder cisterns is one compartment. When the udder is prepped this likely causes local teat muscular control to relax, making the cisternal milk readily available. The interval from teat prep until oxytocin is released and transported via the blood supply to the udder requires approximately 60-90 seconds and this is what controls release of the alveolar milk. Milk in the alveolar system represents approximately 70-80 % of the total udder contents. Early lactation multiparous cows especially have enough cisternal milk readily available that when milking units are attached milk flow into the cluster starts almost immediately. This must be replenished however after

Figure 1. Milk flow graphs illustrating good and slow letdown.



Source: Quality Milk Production Services, Cornell University, Ithaca, New York.

approximately the first 30 seconds of milking with milk released from the alveoli in order for the flow rate to increase continually throughout the first 60-90 seconds of machine attachment time. Otherwise there may be a pause between the end of cisternal milk release and the start of alveolar milk release. This pattern may differ somewhat for first lactation animals due to less cistern capacity.

This is evident when looking at milk flow graphs (Figure 1). If units go on and there is a rapid and continuous increase in milk flow rates to a maximum, then alveolar milk release has overlapped the cisternal milk release resulting in a classic milk flow curve. If there is a first release of some milk then a period of little flow followed by a second more significant increase, it results in a bi-modal milk flow pattern. In this case after the cisternal milk was depleted there was a likely delay before the oxytocin release caused alveolar milk release. This delay means for a period the teat is empty and being compressed by the liner with little or no milk flowing through the teat orifice. This condition is considered to be one of the milking related factors contributing to development of hyperkeratosis or teat end rings.

The second significant cause of teat end hyperkeratosis involves the liner collapsing on an empty teat at the end of milking when little or no milk flow is occurring. This duration should be minimized by removing milking units promptly when flow rates have reached a predetermined low flow rate. The recommendations for low flow rates today are higher than traditionally used and that raises two issues. Will it leave too much milk in the udder and will it lead to more mastitis?

Stewart et al. (2002) monitored closely milking performance in several herds where detacher activation flow rate settings as high as two pounds per minute were coupled with shortened cluster removal delay settings. They found no effect on milk yield and machine on-time was reduced by 10-15 seconds per cow. Magliaro and Kensinger (2004) in controlled studies found small yield

reductions when using a 1.7 pound/minute setting for detacher activation, but levels less than this produced no reduction. These two studies involved different cows with different productions levels, but both suggest that higher flow rate settings can be used to activate detachers than traditionally used with no impact on total production.

There is a good deal of farm-to-farm variation on what is acceptable in terms of how *wet or dry* cows are milked, so it is best for individual farms to make adjustments that appear best for their herd rather than apply a setting recommended by another dairy. Make adjustments in reasonable increments and monitor the results.

Pre-Milking Teat Sanitation, Pre-Dipping, and Pre-Dips

Item 13r of the PMO states that the teats and udders of all lactating animals shall be clean and dry before milking. Teats shall be treated with a sanitizing solution just prior to the time of milking and shall be dry before milking.

Teat skin is not easily sanitized. It has cracks and crevices where bacteria can lodge and be protected. Also, in modern milking facilities time allotted for this task is limited.

Galton et al. (1985) indicated a highly effective pre-milking teat sanitation procedure involved applying a fast acting pre-dip to teat skin, allowing at least 30 seconds contact time followed by wiping the teats clean, and drying with single service towels. Doing so reduced the initial skin bacteria load by 85 %.

Pre-milking teat dips (**pre-dips**) must penetrate quickly into skin cracks and crevices to loosen soil and maximize contact with bacteria that are present. The surfactants used in pre-dip products determine how effectively this occurs. They must also kill bacteria quickly and effectively while teats are coated with pre-dip and there must be no gaps in effectiveness against various species. Users should ask suppliers for data regarding speed of kill and overall efficacy of pre-dip products. There are differences, so make certain to get what is needed and what is paid for. Fast acting iodine pre-dips with high free iodine concentrations meet these requirements.

Diluted bleach solutions are occasionally used as pre-dips. Bleach is a very potent germicide; HOWEVER, it is most effective on previously cleaned surfaces. It has poor soil penetrating ability, does not function well in the presence of a heavy soil load, and it can be harsh on skin tissue.

How Does Pre-Dipping Relate to Mastitis Control?

Teat skin, even on teats that look reasonably clean, may include large numbers of coliforms, streptococci, and other bacteria species commonly found in manure and soil. It may also include *Staph. aureus* and other species of staph and streps associated with cracked or injured skin. All of these potentially can cause mastitis if they enter the gland. Therefore, minimizing their numbers on teat skin prior to attaching the cluster is necessary for mastitis control as well as milk quality. Pre-dipping with effective products helps accomplish this.

What Does All This Mean in the Parlor?

- The udders and teats of cows entering the milking center should be as clean as possible so milkers don't spend extra time cleaning them.
- The fast acting teat dip labeled specifically for use as a pre-dip needs to be applied by spraying or dipping so that it coats the entire surface of the teat and it should be rubbed into the teat ends with the thumb.
- Allow at least 30 seconds of skin contact time. Work routines need to be configured so this occurs.
- Thoroughly wipe the teat and teat ends clean and dry with towels, paper or cloth. Cloth towels tend to remove soil a bit better because of the surface nap of the cloth. Use a clean towel/cow to prevent cow-to-cow transfer of contagious bacteria pathogens.

Post-Milking Teat Dips and Teat Dipping

When milking units are removed each teat needs to be coated with a dip that has successfully passed National Mastitis Council (**NMC**) efficacy testing. These products, for the most part, are listed in each annual NMC proceedings and companies should also have this data available. Make sure the product selected has proven itself to be effective in reducing new infections. As simple as the concept of post milking teat dipping is, it remains the single most effective mastitis control program available.

The post-dip needs to coat the whole teat surface and teat end. If areas are missed due to sloppy application *Staph. aureus* and other mastitis pathogens may survive, grow, and potentially create new infections. Milkers must be provided the tools and be instructed about how to do this job correctly. Poor procedures often lead to serious mastitis issues.

The teat dip formula chosen may also incorporate varying amounts of emollients that help keep skin healthy and free of cracks and chapping. Glycerin is an effective and heavily utilized emollient. It helps retain skin moisture, prevents drying, and also accelerates healing of teat skin that may be chapped and dried out. Healthy, skin is very resistant to major mastitis pathogens, but skin with sores and breaks invites problems.

But teat dip is expensive! Well so is clinical mastitis. Each new case of clinical mastitis may result in costs of at least $100 for discarded milk, medicine, extra labor, etc. (Fetrow et al., 2000). For a 1000 cow herd averaging 4 % clinicals/month, that amounts to 40 new cases or a total expense of up to $4000. Reducing it to 3 % would save $1000. Research has indicated post-milking teat dipping returns approximately $6-8 for each dollar of expense.

Putting It All Together

How must all these factors get tied together to have a successful milking operation?

First, cows need to enter the milking center clean and dry. Dirty cows mean reduced parlor throughput, more risk of mastitis, elevated cell counts, and occasional high bacteria counts. Cows entering the milking center (static parlor) should proceed directly to the first open

stall and a milker should start prepping cows as soon as 3-4 are in place.

Step one should involve wiping off any debris and dirt that is visible on the teats. The next two steps generally involve forestripping and pre-dipping or vice versa. Despite opinions favoring one or the other of these sequences there are no studies in peer reviewed journals demonstrating one is better than the other in terms of mastitis prevention or milk quality so long as both steps are done properly.

A decision to not forestrip to save time and increase parlor turns carries consequences. It eliminates any possibility of checking foremilk for garget, off-color, etc. It also removes a strong letdown stimulus from the pre-milking routine. It will save 6-8 seconds per cow in the pre-milking procedure. This is a management decision. Forestripping, as indicated earlier, may not be necessary, especially in early lactation cows, to elicit a full letdown if other pre-milking procedures are done effectively. Generally, however, it is an integral step in preparing cows to be milked.

A decision to not pre-dip to save time also brings a significant risk. The bacteria reduction on teat skin when quality pre-dips are applied properly will be lost and this will increase the risk of environmental mastitis and increased milk bacteria counts. Such a management decision needs to weigh carefully the pros and cons. If pre-dipping is not done, the time savings per cow may be 10-12 seconds for applying and wiping off the pre-dip. Is this time savings worth incurring the risks? Not pre-dipping or wiping teats also eliminates the positive stimulus it provides for effective milk letdown.

Research cited earlier strongly suggests that once the teats have been stimulated for 15-20 seconds the oxytocin effect and milk letdown will occur in approximately 60-90 seconds. For this reason the milking unit should be attached 60-90 seconds after teat pre-dipping/forestripping has been applied. This will assure milking units will be attached to plump teats after milk letdown has commenced. The milk flow should rapidly move to its maximum without a slowdown after the initial cisternal milk is removed.

This means a milker can normally prepare 4-6 cows, forestripping and pre-dipping and then go back to the first cow and wipe teats clean and dry and attach units. This will allow adequate pre-dip contact time and will assure units are consistently attached within 60-90 seconds of the teats being initially prepped. After each block of cows has units attached the milker can move to another block.

When each cow is done milking and the unit removed, each teat needs to be completely coated with a quality post-milking teat dip to assure destruction of mastitis pathogens. It can be sprayed on or applied by dipping. So long as the coverage is complete the protection will be similar, but teat dipping frequently assures better coverage.

Milkers cannot make the decisions about the details of the milking procedure. Management must provide a written description of the milking protocol and provide training to all milkers so they understand clearly what is expected and why. It is the responsibility of shift managers to be sure the procedures are followed.

Time Allocation During Milk Procedures

Every step in the milking routine takes time. Jones (1998) has described the 3600 second rule. The number of cows one person can milk/hour will be limited by the number of tasks and the time required for each task. If six tasks per cow are required and they consume 36 seconds total, a milker can milk a maximum of 100 cows per hour. Assuming a need for including 10 % idle and miscellaneous time, the result would be 90 cows/hour.

If the objective is to milk more cows per hour/man then either the number of activities or the time per activity or both must be reduced. This is where decisions become difficult. Theoretically it is possible to do both, but at what point does it result in negative results and at what cost?

Cow entry time is a function of how well cows enter when the entry gate opens. The time spent wiping udders and teats clean is dictated by how soiled cows may be. Obviously the cleaner the better. In order to minimize the bacteria load on teat skin, meet the PMO requirements, and provide some pre-milking stimulation; pre-dipping is the best option. Forestripping is considered an effective way to check milk quality and to help stimulate letdown; and it often is combined with pre-dipping, so that two tasks are done at one stop. Wiping teats dry is essential to remove soil, bacteria, and eliminate milk residues of pre-dip before units are attached.

Ranges in the time required for each task have been compiled and table 1 provides benchmark estimates.
Using these estimates, in a parallel parlor completing all these steps per cow may require 45-48 seconds including idle time. Many dairies are able to reduce this

Table 1. Essential milking time tasks and estimated time requirements

Activity-Essential Tasks	Parallel Seconds per cow	Herringbone Seconds per cow
Cow entry	4	5
Pre-Spray	4	4
Pre-dip	5	5
Forestrip	8	8
Wipe	6	7
Attach	10	10 8 for arm units
Reattach	1	1
Post spray	3	3
Post dip	4	4
Exit (rapid exit)	2	2
(conventional exit)	5	6
Misc idle time	15 % of essential task time	15 % of essential task time

Source: N. St-Pierre, 2002

to 30-35 seconds. If they required 36 seconds, one person could milk 100 cows per hour. If more is expected, decisions have to be made. If pre-dipping is eliminated it saves five seconds. Potentially this means another 20 cows per hour, but at what cost? No one but the managers can make the decision, but based on this type of information they can see, in advance, what those trade-offs may be.

Those who work extensively with herd mastitis and milk quality issues likely become biased. When herds have high or increasing cell counts or excessive clinical mastitis, inevitably a careful evaluation is made of cow cleanliness, milking routines, pre- and post-milking products and procedures, dry cow housing, and management. Within those areas lie the answers. Dairy producers benefit from having these deficiencies pointed out and frequently it is a combination of out-of-control procedures, inconsistent execution of procedures, emphasizing speed over doing each task correctly and in the proper time frame, and lack of attention to details, such as assuring proper teat coverage with teat dip.

The difficulty is there is no absolute way of determining in advance what the impact will be in the short- and long-term so every dairy has to experience it for itself and then adjust accordingly.

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