Milking Protocols at the Cal Poly Dairy Farm

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Kevin Mohan

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ABSTRACT

Milking parlors are the center of a dairy operation and directly responsible for its profits, yet dairy training is frequently neglected and often lackluster. The Cal Poly dairy farm, despite having a milker pool that is comparatively inexperienced with farm labor has no written manual for training of milkers. This results in a workplace that in the event of an accident or point of confusion leaves workers nowhere to turn to for clarification save contacting a supervisor directly. It also may also result in a lack of established guidelines, and a frequent need for clarification due to misunderstood expectations and lack of protocol. This is a detriment to the potential of the milking staff at Cal Poly, and by extension to farm profits, efficiency, overall cow health, and facility conditions as a whole. Farms are much more efficient, cohesive workplaces when a written set of expectations, procedures, and definitions of tasks, roles and responsibilities is present. For the sake of workers' safety, profitability, efficiency, and effective completion of assigned tasks, a manual is an essential for any professional dairy farm. Further, a regimen that includes signage and training programs results in a stronger workplace culture responsible for the breeding of professionals. The creation of a milking parlor protocol and workers handbook is therefore imperative to the evolution of the workplace environment and overall effectiveness of the Cal Poly dairy. The creation of this will require research of the scientific basis for current procedures employed by the industry, and a review of Cal Poly's milking parlor procedures to determine that they are in line with the current industry standards. This protocol will help to shape the efficiency, safety, and communication in the workplace, while providing employees with a resource with which to inform themselves about the expectations and procedurals of said workplace.

Key Words: mastitis, best milking practices, dairy parlor, standard operating procedure

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INTRODUCTION

Milking parlors are at the very heart of every dairy operation regardless of size, income, and business model, number of employees or farm layout. From small organic dairies which consist of flat barns and pasture feeding to large scale industrial dairies with free stalls and a TMR system, the dairy farm begins and ends with the milking parlor. Milking parlors are of vital importance to the economic viability and vitality of a dairy operation; without the parlor the farm's reason for existing and return on the high risk investment cattle present would be reduced to nothing. The dairy parlor represents the zenith of all the work that goes into feeding, treating, observing, breeding, caring for, and bringing to term a dairy cow over the course of its pregnancy and ensuing lactation cycle. It is a chance to earn back all the time, money and energy invested in the cow which up until this point has had a free ride and been nothing but a constant investment of capital and commitment.

This is also the point where lost profit is felt most acutely. Unless a dairy parlor establishes an efficient, well managed standard operating procedure with which to govern the vital task of milking the cows, a hemorrhaging of money will occur due to milk lost through accidents and contamination, lost potential milk when cows are improperly milked out and decrease production as a result, and lost capital from inefficient employment of labor which results in overlong shifts and a lack of production proficiency. As stated by David Watkins in *Milking the Dairy Cow*, after as little as twenty milkings at less than seventy-five percent milk out, the lacteal production of the cow may be adversely effected (Ensminger, 1977). Further, the health of the cow may be negatively impacted by rough handling in the parlor, resulting in stress factors that may put her off feed or physical maltreatment that will make her unsteady on her feet. Cows may also develop mastitis and other milking complications from inconsistent or

insufficient milking hygiene or incomplete milking out as mentioned above. Milking time also affects the labor regimen on the rest of the dairy. Inefficient work shifts in the parlor will result in lags in operational efficiency on the rest of the dairy as other employees are forced to wait or slow down to compensate for overly sluggish workers in the parlor. As the most public face of a dairy, the inexperience or amateurism in the milking parlor will result in a negative perception of a dairy by the public, something the dairy industry can ill afford.

The aim of this study was to determine what proper scientifically based protocols for milking parlor setup, teardown, cleanup, maintenance and operation entailed, as well as proper milking procedure for a cow, and to develop an effective delivery system that hammered home the details and practicalities of this system to employees in the form of a multimedia training program.

LITERATURE REVIEW

In the effective management of a milking parlor there are a myriad of considerations to document, from parlor construction, to specifications of the milking parlor's design, to the steps outlined in the training regimen implemented by the management of the dairy. Essential for a proper milking system is all equipment necessary to collect, cool, and store milk. Also essential is proper performance of all protocols from proper hygiene, to diligent maintenance of equipment, to consistent, safe and thorough milking of all cattle. All play a role in the most vital of processes on a dairy farm, and all are necessary to ensure effective, safe, efficient harvest of milk and maintenance of optimal cow health.

Parlor Configuration

For reasons of hygiene and ease of maintenance, a parlor/freestall milking system is desirable over previously dominant tie stall and flat barn set ups. Advantages offered by a parlor/dry lot system include lower initial building costs compared to other more archaic styles of farm, concentration of milking equipment and production equipment in their respective buildings for easier supervision and maintenance, the need for labor intensive daily cleaning of a tie stall barn is averted, as well as the ability to produce high quality milk with less trouble (Staker, 1989). This particular layout of milking parlor leads to an easier conversion of the buildings for other purposes should the dairy function at any time prove to unprofitable to continue, and that better overall cow health and specifically better knee and hock health among the herd will result (Staker, 1989). The variety and design of a farm's milking parlor will be selected based on a number of factors specific to each farm including type of cow, number and organization of milking units, size of herd and the milker's routine (Staker, 1989). Lighting is also essential to an effective milking regimen and that fluorescent strip lighting has been found particularly effective (Staker, 1989). The use of 80-W natural or warm white fluorescent bulbs with open top or translucent plastic reflectors is recommended for parlor use, although they also field the recommendation of one 60-w lamp per 150 square feet of floor space, while stating that one lamp per every two milking stalls is ideal if at all possible for abreast type milking parlors such as those employed by the school (Staker, 1989).

For natural lighting, the use of window skylights and corrugated metal lighting sheets placed over the side windows in the operator's portion of the parlor is ideal (Staker, 1989). Both of these configurations are present on the Cal Poly dairy. It is also imperative that windows be placed above cow level to avoid their destruction (Staker, 1989). Ventilation is also essential, with rooftop ventilation at the ridge and the previously mentioned hopper type windows being

the most effective at catching and channeling a cross draft of prevailing windows through the parlor (Staker, 1989). Horned, ridged or raised ventilators may be chosen depending on the amount of precipitation present in the area of the building's construction (Staker, 1989). In a temperate climate it is recommended that the parlor be built with top sections of walls and the area through which cows enter entirely open, with three wall parlors being ideal for ventilation and heat/cooling purposes in temperate climates (Staker, 1989). Different types of milking parlors listed are as follows: A single abreast milking parlor in which the cows stand by side on the same level with the operator. Two level abreast milking parlor, where the stalls are placed above the level of the parlor floor to save the strain of bending over for the milkers in the parlor (Staker, 1989).

Configurations include herringbone where cows enter at an angle forward, parallel where cows stand perpendicular to the milking pit or alleyway, and rotary parlors where the cows enter onto a carousel and rotate for the duration of their milking before backing off the carousel and exiting via a different door (Bickert et al., 2000). Other configurations include swing parlors, side opening parlors, and flat barn milking parlors (Bickert et al., 2000). While Lough advocates a herringbone setup (Ensminger, 1977), Wilcox and Van Horn (1993) recommend a rotary parlor, while other authors advocate a parallel parlor. The consensus over which parlor presents a superior milking setup has varied widely over time, and most farm management advisors now concur that no one setup is superior, it is mostly the management practices that most fully utilize their chosen setup that result in effective milking strategies, and farm owners should chose the setup that best fits their labor and geographical needs. Many of the authors sampled maintain that developing a constant, thorough and consistent program is the key to an effective farm, not a particular style of parlor. When selecting a configuration, the imperative is designing a parlor

which works for the realities of the farm it is designed for (Bickert et al., 2000). Other considerations when building a parlor include spaces for a storage room for spare machine parts and filters etc., a utility room for storage of the machinery to power the parlor, a milk room to store the bulk tanks, an office for records, employee areas such as showers, break rooms and lockers, and bathrooms (Bickert et al., 2000). A source of water must be obtained for the parlor that is either approved by the agricultural authority present in the farm's state of operation and piped in, or be chlorinated to 50 ppm to before usage (Staker, 1989). A storage room should be well insulated so that storage temps remain between 40 and 80 F to avoid deterioration in stored components (Bickert et al., 2000). Bulk tank storage rooms should be kept free of dust and odors by way of adequate screening and ventilation (Bickert et al., 2000).

Organization

One of the key points of managing an effective milking regimen is pen size and organization. The Dairy Science Handbook (1977) states that fundamental planning concepts are key in expanding the production horizons and efficiency of a dairy parlor. Key to effective milking begins with proper division of cattle into manageable units. If the pens are too large and cows are waiting too long in individual pens, stress factor will be greatly increased inhibiting oxytocin stimulation and milk let down (Ensminger, 1977). Pens that are too large will also result in milker fatigue and decreased transitions time between pens, while also resulting in damage to cows from overcrowding and jostling by overly dominant cows and those in standing heat (Ensminger, 1977). Cows will often compete for dominant positions and once they have obtained them will remain in such a position for the duration of their stay in the herd (Peterson and Field, 1953).

The separation of cows into pens organized by size is an effective way to ensure that smaller cows are not bullied or trampled by elder or larger cows with a more aggressive attitude (Wilcox and Van Horn, 1993). Overly large pens can also result in management problems where workers are faced with a daunting task in moving and supervising overly large pens and are stretched far too thin in doing so.

When designing the layout of a parlor building, milking labor should determine overall parlor design (Ensminger, 1977). "The very nature of the job makes milking labor the most potentially dangerous, demanding, costly and difficult to supervise in the entire dairy operation," states Lough in *The Dairy Science Handbook*, "Therefore, the highest priority is given to designing a milking system where one milker can milk the most cows efficiently (Ensminger, 1977)." It is further stated that a parlor requiring one to two milkers is ideal as it will "reduce friction among milkers, pin-pointing responsibilities and result in easier supervision of this critical operation (Ensminger, 1977)." Percent efficiency of milkers declines rapidly after four hours without a rest break, and a rest period of thirty minutes is necessary if a shift longer than 4 hours is to be milked (Ensminger, 1977).

Many industry professionals advocate a system where parlor design determines total design, with the rest of the farm designed to support the milking system (Ensminger, 1977). The importance of planning for an orderly expansion to parlor capacity as an eventuality instead of a distinct possibility as this will later permit for easier farm expansion should it become necessary is also a consideration (Ensminger, 1977).

Further recommendations include that milking parlors should also slope at least 1-4% or greater in order to facilitate effective drainage of waste, backflush and dirt (Ensminger, 1970). The holding pen should be sized to hold 1 1/3 times the hourly capacity of the milking parlor so

as to facilitate continuous milking as the next pen of cows can be moved into the parlor as the first pen is being milked after about 2/3 of the previous have been milked (Ensminger, 1977). The pen should allow for 14-16 feet depending on breed size (Ensminger, 1977). Crowd gates should also be installed with a positive safety cut-off switch activated by cow pressure where possible (Ensminger, 1977).

Milking Hygiene

Where milking procedures are concerned, hygiene is key. Work conducted at the National Institute for Dairy Research in Reading, England revealed that under ideal hygienic conditions it is possible to achieve a reduction in the new infection fate of 64% for Staphylococci and 70% for Streptococci (Ensminger, 1977). To achieve these results, Wittlestone recommended that the following procedures be recommended as essential for usage in dairy parlors. Smooth rubber gloves must be worn at all times both to prevent the spread of infection from the cow to the milker, and vice versa (Ensminger, 1977). Crevices on the hands are ideal carriers for stubborn bacteria even if hands are washed between sides of cattle, and the unhygienic state of human skin results in unsanitary spread of bacteria between milker and bovine (Ensminger, 1977). Gloved hands should be rinsed with disinfectant between strings if at all possible, and changed whenever a cow with mastitis is encountered (Ensminger, 1977). Washing of the teats with pre-dip is absolutely essential to proper milk hygiene (Ensminger, 1977). Automated washing stations can be successful in softening of manure caked on the udders before milker wipes them, however it is still imperative that the milker be responsible for ensuring udder cleanliness before attaching the milking unit (Wilcox and Van Horn, 1993).

Listed below is the Pennsylvania State Dairy Extension Service's list of best practices. These practices represent a good general guideline of accepted milking practices on a modern dairy farm.

1. Observation of Cow Cleanliness. Is there manure on the udder and teats?
2. Observation of Parlor and Equipment Cleanliness.
3. Are employees using gloves?
4. Proper use and coverage of Pre-dip. Test proper coverage with "Paper Towel Test"
5. Length of time dip is on teat before drying. (Follow Label most 15-30 seconds)
6. Is the employee stripping each teat vigorously and getting good milk flow?
7. Is a strip cup being used? This can help to detect early cases of mastitis and decrease change of pathogen spread.
8. Is CMT test being performed on animals that are suspected to have an infection?
9. Is water being used to clean udder? No Water should be used. Aids in bacteria growth.
10. What is the milking preparation procedure? Dip-Strip–Dry–Apply (Dry must be the last step before application of unit)
11. Are teats being thoroughly dried (including teat ends) before unit attachment? (Clean **Dry** Towels) Test teat end cleanliness with "Alcohol Swab Test".
12. Are teats farthest away from milking being dried first? (reduce risk of recontamination).
13. What is the time from first contact with the teat until the unit is fully attached? This is referred to as Lag Time. Should be between 60-90 seconds.
14. Are units properly adjusted to squarely hang under the udder?
15. Are employees properly using the automatic take offs? (Should not be switching to manual).

16. What is the length of time from until attachment to unit removal? This is referred to as "Unit On Time." This should be 3.5 to 5 minutes in length with proper milking stimulation.
17. Observe teat ends of damage or tops of teats for purple ring.
18. Are employees getting proper post dip teat coverage? Use the "Paper Towel Test".
19. Are all employees following the same procedure. Consistency is very important.
20. Observe milk filter post milking for dirt or mastitis.

Penn State's guidelines above (PSUFS, 2013) serve as an effective summary of many of the diary parlor control points touched upon by other authors. Most important for effective and complete milking out of cows as stated by all of the above authors is effective pre-dipping and stripping to stimulate the release of the hormone oxytocin and the milk ejection reflex. The cow is in nature stimulated by the suckling of the calf. The pre-dipping step acts as a substitute for this act by providing a similar sensation as well as anti-bacterial protection (Tyler and Ensminger, 2006). Once milk letdown is stimulated the teat ends will be open and it is imperative that any bacteria present near the mouth of the streak canal and teat opening are eradicated to prevent contamination and infection. Wiping serves a drying function, as well as cleaning off visible filth to prevent infection or adulteration of the milk harvested (Tyler and Ensminger, 2006). Two-thirds of the teat must be covered in a pre-dip solution as a general goal to ensure a decent zone of inhibition between the teat opening and any remaining bacteria. The same is true of post dip once applied (Tyler and Ensminger, 2006). Post dip is absolutely imperative as the cow is most vulnerable to infection as she leaves the parlor to return to dry lots or free stalls as her teat ends will be wide open and prone to infection (see fig. 1 for potential pathways of infection). Post dipping with an Iodine or Propylene Glycol based post-dip will

drastically reduce the incidences of infection (Tyler and Ensminger, 2006). Complete milking out of a cow's udders is also essential. For rational see the Milk Letdown Reflex section.

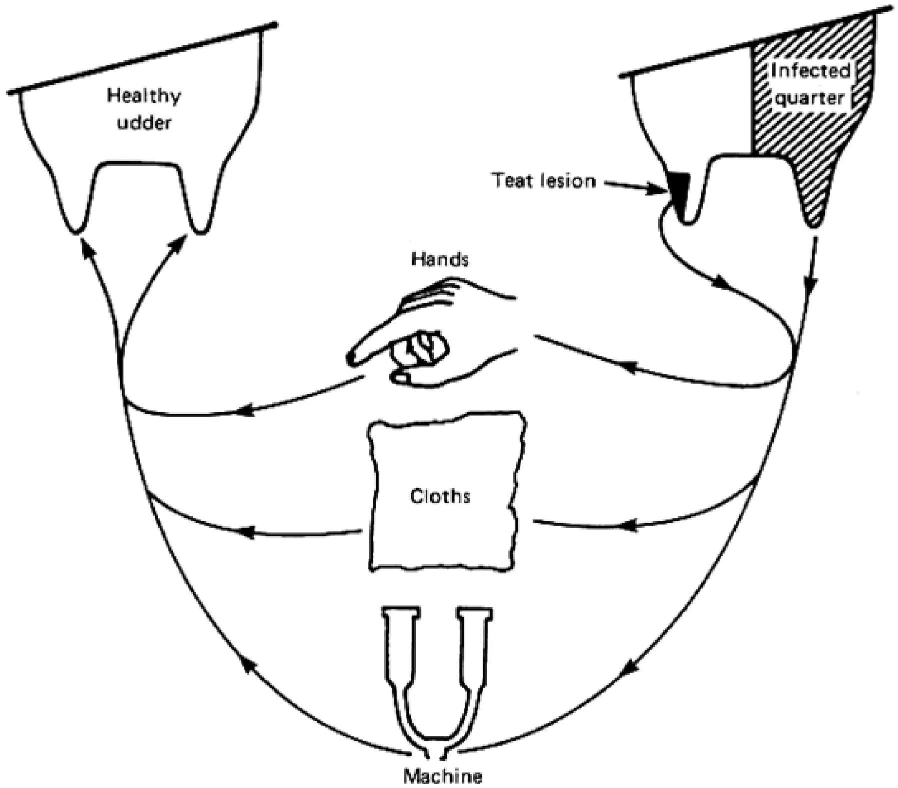

Figure 1: Pathways effecting spread of mastitis bacteria

Food and Agriculture Organization of the United Nations, 1989, Staker, *Milking, milk Production, Hygiene and Udder Health,* *http://www.fao.org/docrep/004/T0218E/T0218E00.HTM*

Milk Letdown Reflex

When discussing milking procedure it is impossible to avoid mention of Milk Letdown Reflex, as it is crucial to the milking process. While the phenomenon is common knowledge among anyone who comes into regular contact with a milking parlor or cow, the science behind it is more obscure. The theory is as follows: In order to extract milk from the udder, the streak canal in each of the teats needs to be open (Tyler and Ensminger, 2006). This is accomplished by negative pressure during machine milking. During hand milking, positive pressure on the teat

cistern results in ejection of milk through the streak canal (this is what occurs during stripping to stimulate initial milk letdown as well). Without this ejection reflex, milk cannot be fully extracted from the upper mammary system such as the lumen of the alveoli and smaller ducts. 80 percent of milk stored in the udder at any point is stored in the collecting ducts, milk sinuses and cisterns (Tyler and Ensminger, 2006). When improper stimulation of milk letdown occurs, only the minority portion of milk located in the teat and gland cisterns and globular ducts will be released. To stimulate proper milk letdown, manual stimulation of the teats is required. The nerve receptors stimulated in the teats are part of the spinothalmic system which responds to abrupt stimuli (Tyler and Ensminger, 2006). The pressure sensitive nerve receptors located in the dermis of the teats react to this stimulation by sending nerve impulses to the afferent nerves. For maximum stimulatory effect, ten seconds of stimulation is ideal (Tyler and Ensminger, 2006). This process of milk ejection is the result of high intensity long duration stimulation. Conversely however, the release of oxytocin which stimulates a higher brain function response that may correlate to milk ejection. This forebrain response to conditioned stimuli of milking (I.E. the sights and sounds associated with milking) resulted in a release of oxytocin and milk letdown in about 1/3 cows observed (Tyler and Ensminger, 2006). After the release of oxytocin, it is synthesized in the paraventricular or supraoptic nuclei. Following synthesis, it binds with neurophysin I to form neurosecretory granules, or storage granules (Tyler and Ensminger, 2006). Transported down the nerve axons, granules are stored in the herring bodies, swollen areas along the neurons. These granules are used for storage, and also contain a reservoir of oxytocin in their posterior pituitary gland available for ready release. Oxytocin stimulation causes myoepithelial cells around the alveoli to contract while simultaneously causing the dilation of small ducts (Tyler and Ensminger, 2006). These myoepithelial cells can also be stimulated manually to

release milk. These conditioned responses are another effect that belies the crucial nature of pre-stripping in milking parlors, both to provide direct stimulation to enhance milk secretion and to trigger the conditioned response of oxytocin release and milk letdown (Tyler and Ensminger, 2006).

In a study cited by Ensminger (1977) in the Dairy Science Handbook Vol. 10, it was found that after as little as twenty milkings at 75% milk extraction, lacteal production was inhibited in the subject cattle. Assurance of proper teat stimulation is therefore essential. However, it is also imperative that teat ends not be overstimulated and damaged by over milking. The optimal attachment interval that straddles the two is to attach machines within 45 to 90 seconds after teat stimulation (pre-stripping). Oxytocin has an extremely limited half-life of 1.5 to 2 minutes in the blood stream. Oxytocin levels spike immediately after stimulation of the teats, and following this drops to minimal concentrations within five minutes after the initiation of milking. Concentrations of blood oxytocin mirror intramammary pressure applied, so it is imperative that rapid and thorough milk out be achieved. The first stimulation cannot be followed immediately by a second stimulation of release (Tyler and Ensminger, 2006).

Another consideration regarding the milk letdown reflex in the parlor is the role of stress inhibitors in preventing complete milk letdown. As mentioned above, the limited time-life of oxytocin is a key factor necessitating speed in the milking parlor. However, of equal consideration are environmental stressors that result in the inhibition of milk letdown. Farm animals bred for high milk production tend to be highly susceptible to stress and the accompanying immune, physiological and behavioral problems that accompany it (Pajor, Usher, and dePassile, 2000).A key example is stress stimulated adrenaline. This pathway follows accordingly: the cow senses a stressor in her vicinity which triggers a nervous system release of

epinephrine and norepinephrine. These result in vasoconstriction, which redirects blood flow, reducing the amount of oxytocin able to reach the myoepithelial cells. Emotional stress of the animal is most linked to the release of norepinephrine, which blocks neurons in the paraventricular nuclei from firing (Tyler and Ensminger, 2006).

This will result in impaired milk let down, which might lead to mastitis, painful edema and udder rashes from the cow's swollen udders, and in addition will lead to a decrease in milk production that may remain for the rest of the lactation (Tyler and Ensminger, 2006). For this reason, minimization of stressors and proper performance of all milking tasks in a standardized and prompt manner is essential. While the dipping and stripping steps are of key importance, all steps performed in an unobtrusive, predictable manner will act as a stimulator for the condition response oxytocin release. Therefore, consistency and completion are the keys to milking, In the event that the cow will not let down her milk, the use of exogenous oxytocin shots in the parlor might be considered in extreme cases (Tyler and Ensminger, 2006). This method will not resolve peripheral blockage of milk letdown, but in cases of central inhibition stimuli oxytocin shots may prove effective. The injection of oxytocin allows for the re-milking of the cow, and even for the harvest of residual milk (the 10-15% of milk normally remaining at the end of milking, though this decreases over the duration of the lactation as overall milk yield increases) (Tyler and Ensminger, 2006). Ten International Units of oxytocin injected twice daily was found to greatly increase milk production when the cows were re-milked. It was found that as the lactation progressed, milking yield dropped as re-milking yield increased however (Tyler and Ensminger, 2006). Additionally, constant use of oxytocin will interfere with the cow's ability to stimulate milk release normally from her myoepithelial cells (Tyler and Ensminger, 2006). Hence, repeated use of oxytocin shots is not desirable.

Equipment

Milking in a parlor setting follows one of two general types of system: bucket or pipeline (see. The former involves milking directly into a portable vacuum sealed bucket, which sits on the floor or suspended. It is uncommon to see these in a modern milking parlor, they more frequently appear in tie-stall barns and hospital pens, where smaller milking herds are present. In pipeline milking systems, stainless steel pipes carry vacuum to the individual machines from the vacuum pump, and milk from the units to collecting jars and from there to the bulk tank.

Vacuum

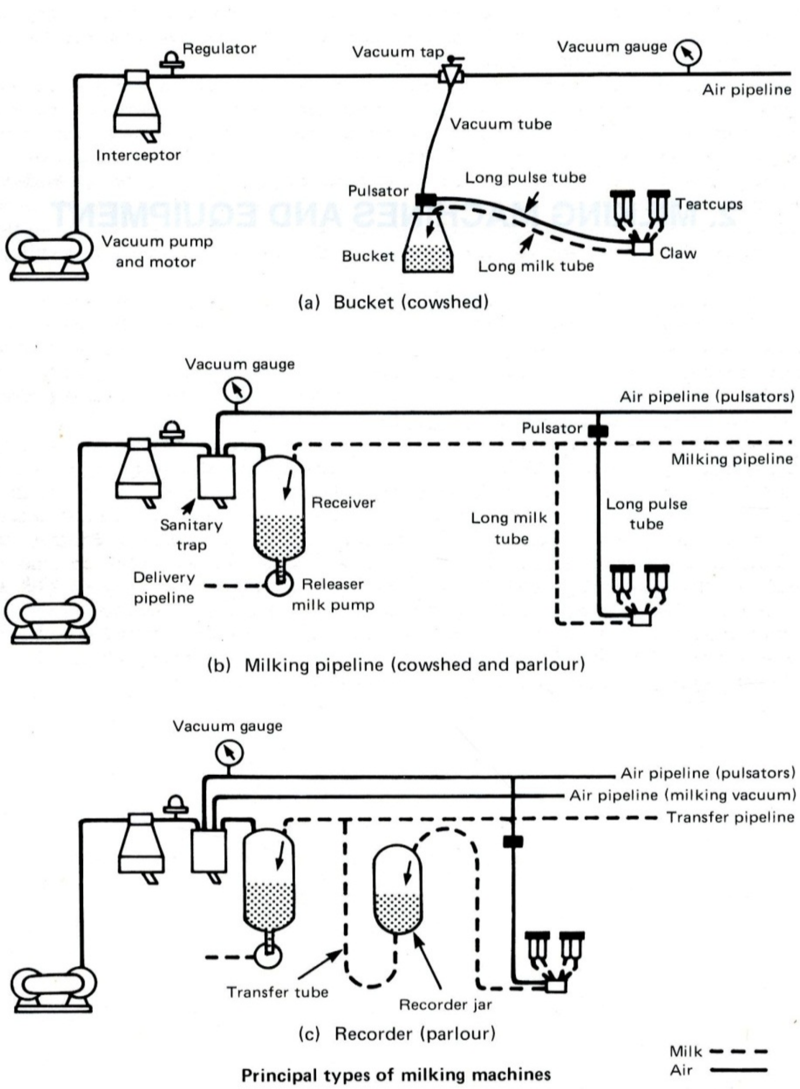

Figure 2: Three main types of milking machines

Food and Agriculture Organization of the United Nations, 1989, Staker, *Milking, milk Production, Hygiene and Udder Health,*

http://www.fao.org/docrep/004/T0218E/T0218E00.HTM

systems are the motors responsible for powering a milking parlor (Tyler and Ensminger, 2006). They are used to control the movement of and displace air (Tyler and Ensminger, 2006). There are two types of vacuum pump commonly used in milking parlors: rotary and piston (Tyler and Ensminger, 2006) Key to the operation of a milking parlor is the maintenance of a proper vacuum level (Bickert et al., 2000). Without it, machines may form weak attachments while

milking, fail to milk cows out thoroughly, and may also cause excessively low vacuum near the receiver. A vacuum pump should be strong enough that the physical drop installed in the line near the receiver is less than .6 inches incline. This need will be met in most conventional milking parlors by a pump with a base capacity of 35 cfm with an additional 3 units of cfm added per milking machine (Bickert et al., 2000). In the case of the Cal Poly milking parlor for example, a pump with a minimum capacity of around 95 cfm would be ideal. Greater amounts of vacuum will be necessary in parlors where the milk line is suspended overhead, as the milk must travel upward instead of flowing with gravity (Bickert et al., 2000). A good general rule of thumb for vacuum systems is to design their capacity at 25% greater than is at base necessary to operate all milking units and to lift and transport the milk to the bulk tanks through the cooling system in a pipeline setting (Bickert et al., 2000). A vacuum reading of 15-18 mercury is generally sufficient to prevent teat cups from falling off without overstimulation of the teat ends occurring (Barnard, Halley and Scott, 1970). A regulator should also be set up in the line to control the vacuum at a constant level. This regulator remains partially open during milking, and opens to admit more air should the vacuum level rise to high, closing when it falls to low (Barnard, Halley, and Scott, 1970). The pulsator line itself should generally be of loop design, 1 inch per 10 feet and anchored to the wall to ensure stability (Ensminger, 1977). Vacuum controllers should be placed near the trap and if possible between the reserve tank and first stall cock, matched to pump capacity (Ensminger, 1977). Ideally, two or greater smaller capacity controllers are preferable to a single unit in case of malfunction of said unit (Ensminger, 1977). For management purposes the vacuum gage should be in a convenient location operator check, located near the vacuum controller but never in the same pipe fitting (Ensminger, 1977). The *Dairy Science Handbook* also states that gages should be replaced yearly (Ensminger, 1977). It

additionally recommends a vacuum pump capacity of at least ten cubic feet per minute per milking unit and a vacuum reserve tank capacity of at least 5 gallons per milking unit with a minimum capacity of 20 gallons (Ensminger, 1977). Proper maintenance is also essential for an effective milking parlor (see figure 3 for a list of daily checks).

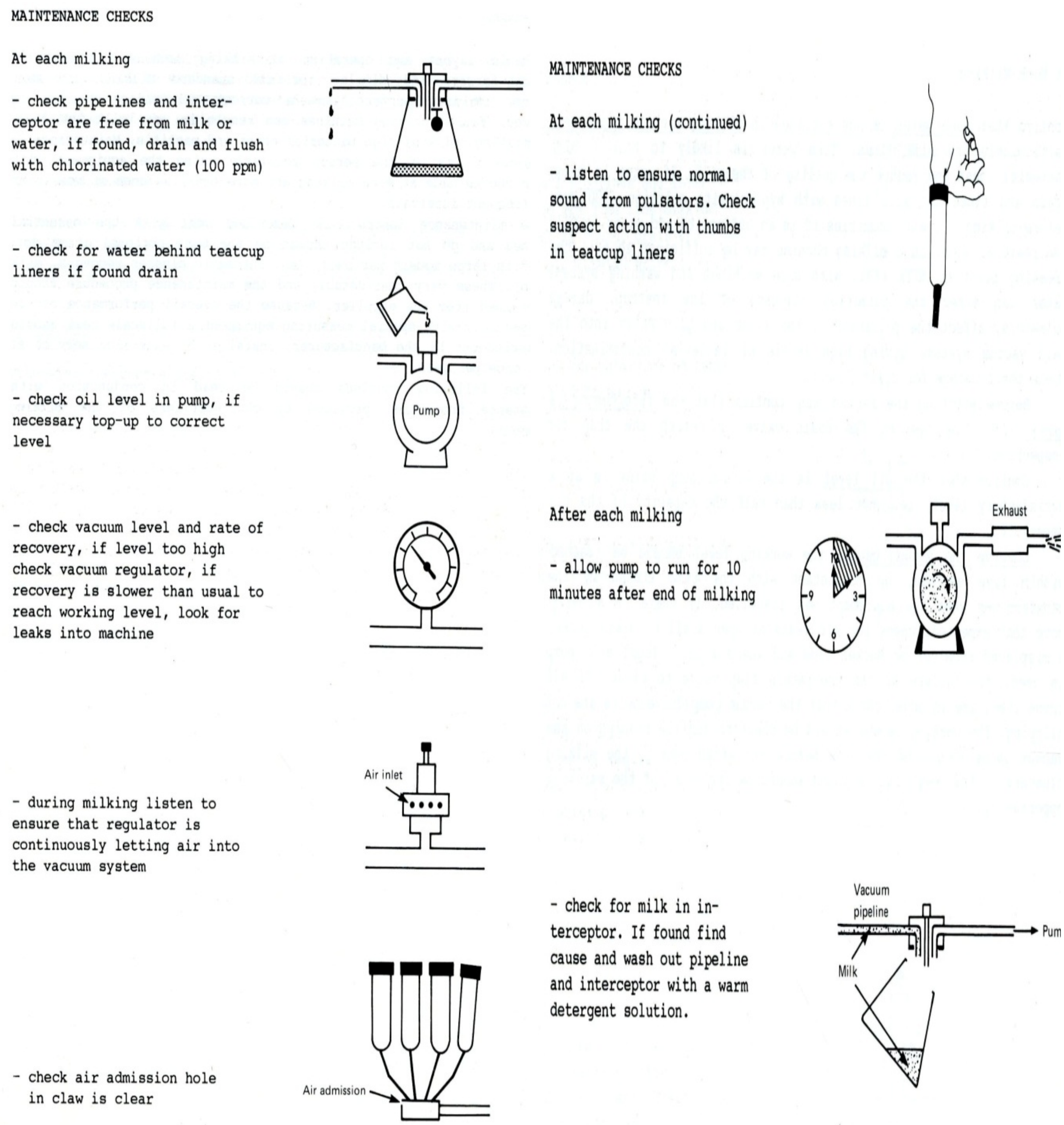

Figure 3: Maintenance checks to be performed at each milking

Food and Agriculture Organization of the United Nations, 1989, Staker, *Milking, milk Production, Hygiene and Udder Health,*

http://www.fao.org/docrep/004/T0218E/T0218E00.HTM

Pulsators are used to direct airflow to and from each milking unit. They cause the inflations (liners) in the teat cups to open and close (Tyler and Ensminger, 2006). These pulsators will be either pneumatic or electromagnetic pulsators. Pneumatic units contain a locking-screw valve used to adjust the rate of pulsation. Electromagnetic pulsators use a timing device to control the rate of pulsation. Electromagnetic pulsators are centrally controlled by a box which sends electric signals to each unit, controlling an electromagnetic plunger which adjusts air movement from the pulsator tubes which feed the milking unit (Tyler and Ensminger, 2006).

These individual pulsator units feed four teat cups, which are stainless steel shells with inflating tubes known as liners that attach into the unit pulsator. The bore sizes of the pulsator vary, with the larger sizes being more prone to irritation of teats, while the small bores, which sit lower down on the teat avoiding the sensitive tops of the teat, are less prone to irritate (Tyler and Ensminger, 2006). Teat liners should be changed frequently, as those which lose their elasticity tend to do more damage to the teats due to the rigidness of their liners producing a harsher motion on the teat (Tyler and Ensminger, 2006).

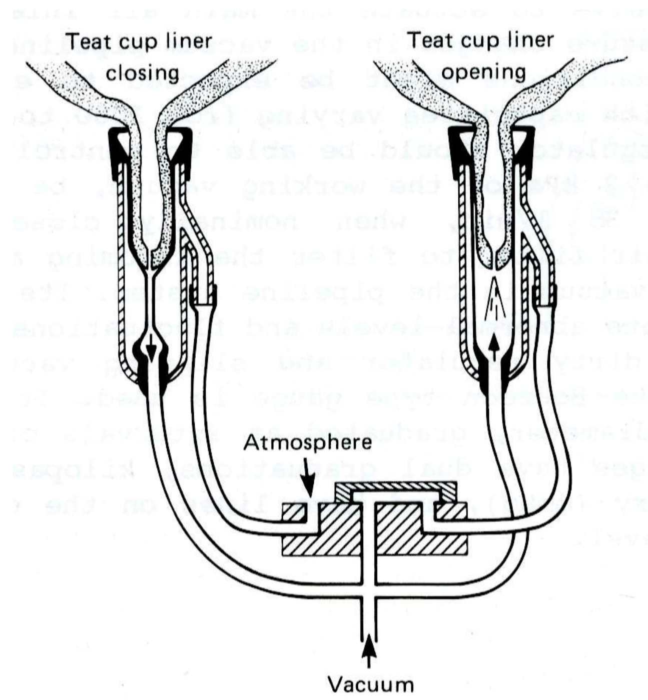

Figure 4: Illustration of the actions of the teat cup liners

Food and Agriculture Organization of the United Nations, 1989, Staker, Milking, milk Production, Hygiene and Udder Health, http://www.fao.org/docrep/004/T0218E/T0218E00.HTM

Milk extraction is adversely effected when low quality or worn out milk liners are used (Barnard, Halley, and Scott, 1970). These milking units operate on a four phase milking pattern; Increasing vacuum, expansion phase, decreasing vacuum, massage (non-milking) phase (Tyler and Ensminger, 2006). In the initial phase, pressure between the liner and the shell decreases resulting in a pressure balance wherein the teat cistern's pressure is greater than the pressure outside the teat, which causes milk to be forced out of the streak canal. This encompasses the first two cycles and is termed the expansion phase (Tyler and Ensminger, 2006) Next the pressure between the liner and the pulsator increases causing the liner to loosen around the teat, and this allows the teat a rest phase where the teat sphincter closes and blood and lymph leave the teat (Tyler and Ensminger, 2006). The rest period serves also to protect the cow's teats from

damage by excessive exposure to vacuum and helps to maintain proper blood flow (Castle and Watkins, 1979). Pulsators should be set at a milk rest ratio from 50-50 to 60-40 to allow for maximum stimulation that will not result in overstimulation or blown teat ends (Ensminger, 1977).

As stated by *The Dairy Science Handbook Volume 10*, pulsation rates are linked in a positive correlation to milking rates, but this is limited by the time required to switch from vacuum to atmospheric pressure and back again (Ensminger, 1977). High pulsator rates are responsible for the significant reduction of the portion of the cycle available for rest periods resulting in cow discomfort and teat congestion visible to the milker in the form of blown teat ends and abrasions on the cow's teats, as well as aggravation, lowing, and kicking on the part of cows in obvious distress (Ensminger, 1977). The ratio of rest phase, when shortened, increases milking rate (Ensminger, 1977). With a long milking phase, there is a diminution in milk flow rate, so a minimum total rest phase of 25% with atmospheric pressure not being less than 10% is recommended (Ensminger, 1977).

Proper cooling is essential as well. To maintain proper quality of milk, milk must be cooled promptly and thoroughly. After collection, milk must be cooled to 40 degrees Fahrenheit or less within 30 minutes to preserve its quality (Bickert et al., 2000). Blend temperature in the tanks should, during later milkings be kept at 50 degrees Fahrenheit or below, as this is the maximum temperature allowed by both federal and state regulators (Bickert et al., 2000). Optimum storage temperature for milk is between 36 and 38 degrees Fahrenheit. Blow 35 degrees Fahrenheit, milk will lose many of its beneficial properties and will experience a lower fat test and rancid flavor after a thin layer of milk freezes to the cooling plate (Bickert et al., 2000). Prompt milking also ensures that any odor or flavor defects held over from the cow or its diet will for the most part

become imperceptible (Baker, 1961). See Figure 4 for illustration of the actions of the teat cup liner.

Systems employed for cooling include a myriad of options depending on parlor set up, volume of milk processed, number of bulk tanks, and a number of other farm design related factors. One of the more common is the conventional compressor/condenser bulk tank system, with the compressor sized determined by milk flow that enters the tank per hour (Bickert et al., 2000). Another system used by dairies is the combination of a heat exchanger and a bulk tank cooler. In this system milk is run through a tube cooler and a plate cooler between the receiver jar and the bulk tank (Bickert et al., 2000). Well water runs simultaneous to milk flow through the heat exchanger to cool it. Cooling time is affected by heat exchanger surface area, water and milk temperature, and flow rate (Bickert et al., 2000). This is the system employed by Cal Poly with its plate heat exchanger and individual cooling units on each of its bulk tanks. A clean in place (CIP) system that allows the cleaning of all pipes and equipment in the dairy parlor without opening the system should be installed to ensure hygienic conditions are present during milking (Coletti, 1963). This CIP wash system should use a mix of alkaline cleaning detergent/acid and water to the order of 1 ounce of the former per two gallons of the later, with the water heated to a temperature of around 160 degrees Fahrenheit and held at that temperature for the duration of the wash cycle (Coletti, 1963). The cold water flushes out the liquid milk residues present in the pipes, while hot water and hot alkaline are used to remove fatty deposits and protein deposits, while hot acid detergents are used to remove the buildup of mineral deposits (Holmes and Wilson, 1984). Increased concentrations of acid or alkaline detergents can be used to remove their respective contaminants if only cold water is available, however hot water is preferable whenever possible (Holmes and Wilson, 1984). Individual formulations and temperatures of a

wash cycle may vary depending on the farm consulted, the abovementioned merely being an example of one viable system. Water should flush through all hoses, lines, milking machines, etc. that are exposed to milk during a shift (Coletti, 1963). It is imperative to ensure that no wash water is retained in the lines after a CIP cycle is run, as this can lead to the buildup of waterborne bacteria and the adulteration of milk (Staker, 1989).

A combination of all factors discussed above, a properly designed parlor, a milking system that is consistent and thorough, and a regimen that ensures the limitation of exposure to bacteria are the ingredients most effective in creating a profitable and efficient milking parlor. The creation of such a milking parlor will result in greater coherence on the job, fewer injuries, greater job satisfaction, and higher profits and animal health.

METHODS AND PROCEDURES

Milking Parlor Standard Operating Procedure

Dairy parlor operating procedures for a parallel style milking parlor were taken from a number of farms, textbooks, manuals and journals and were synthesized and evaluated for effectiveness against theoretical idealized practices by taking into account the factors of overall milking time, reported incidences of accidents occuring in the parlor, cow health in the forms of lameness and mastitis counts for the herd, and average number of cows hospitalized for milking related aillments on a per monthly basis. Once the most effective procedures had been determined, these practices were put to the milking staff and herd manager for evaluation of practicality. Of those determined suitable, these were assembled into an operational manual, training video and informational signage for posting around the milking parlor to assist in the training of present and future milking staff.

Experimental design

A literature review was simultaniously conducted to determine which milking parlor practices were deemed most effective, safe and hygenic for both workers and cattle. These procedures were then synthesized into a list and submitted to the farm manager of the subject farm for review.

Once reviewed to the manager of the farm's satisfaction, the plan was then submitted to the farm's milkers for practical evaluation of implementation. Once the procedures were refined to the satisfaction of staff as was possible, the list was formatted into a standard operating procedure that was then duplicated one copy for the farm manager to keep on file and one copy placed in the clock-in room of the milking parlor building for reference. The procedures stated within were then preformed and taped as a practical training video for demonstrations in instructional meetings. Simultaneously, the proceedings were photographed and assembled into instructional placards that were placed around the milking parlor for milker reference during setup, milking and teardown procedures.

RESULTS AND DISCUSSION

The information that was compiled in the literature review was tabulated and current milking practices for the Cal Poly milking parlor were evaluated. Most of the practices employed by Cal Poly’s dairy were in line with those standardized and held to be most effective throughout the industry. The construction of Cal Poly’s Dairy parlor, the least modifiable aspect of the grounds, was thankfully much in line with what is held to be standard in the industry today. Many of the aspects such as natural lighting, shutters on the windows, non-porous materials such as tile and stainless steel for surface construction, and floor plans which are laid out in a

convenient and open manner not inhibiting traffic flow were already present in the construction of the Cal Poly milking Parlor. Practices employed by the Cal Poly dairy also compare favorably to those employed by the industry at large. Cal Poly's dairy employs the Dip, Strip, Wipe, Attach, Detach, Post-Dip procedure used by the bulk of industrial farms in California at present. Cal Poly lacked an employee handbook, job description for milkers, mission statement available for viewing by milking staff, and a standardized training regimen. Cal Poly's dairy in many ways typifies an amalgamation of the procedures reviewed previously in the literature review. It is a modern scientific dairy run in a fashion that is largely dictated by the currently accepted trends in the industry.

That said however, Cal Poly's greatest limitation was its inability to train and field an effective and professional labor force. This was not the fault of the workers under its employ, more a commentary on the fact that as is so often the case in student dairy farms, students with little to no experience were forced to fill positions for which they were very much undertrained due to sporadic availabilities on the part of the farm workforce as a whole. This meant that in the case of the Cal Poly dairy, students were frequently pressed into service with little to no training on the basis of need, regardless of ability to fulfill the duties required for the job. As is the case in many scenarios of inconsistent management, the problem lies not in the skillset of the workers employed, but in the inability of management to establish clear regulations and expectations, stated duties and job requirements, etc. This breach of communications, detrimental enough under normal conditions in industry was exacerbated by the fact that many Cal Poly students employed by the dairy lack any previous experience working as a milker, and hence lack any practical knowledge as to how to perform on the job. This oversight was not only costly in terms of effectiveness of labor owning to increased wages paid for time lost on the job, as well as

damage to cow health in the form of increased numbers of mastitis cases from improperly milked cows, and cows going without treatment due to lack of recognition of their condition due to inexperienced staff, but also in the cost of mistakes on the job resulting in loss or contamination of milk and by extension the loss of accompanying profit of that milk and loss of labor paid to harvest that milk.

This also posed a danger to employees in that many milkers pressed into service without proper training lacked proper awareness of the hazards and necessary corresponding safety precautions essential to proper performance on the job. This had the potential to result in injuries, expensive lawsuits, and a tarnishing of Cal Poly's reputation as a safe and professional working environment. Clearly the most essential item of revision in terms of Cal Poly's milking department was the establishment of a guidebook for the workers outlining all procedures necessary for performance of milking at the Cal Poly dairy, and to rectify the lack of clarity surrounding the role milkers played in the implementation of the Cal Poly dairy's business plan. Additionally, the creation of the guidebook was designed to resolve the issue of training shortfalls by outlining in clear detail the full extent of duties pertaining to milking and the methodology behind them In the case of guidebook requirements, the most visceral design component was a visual representation of the work expected of milkers, written in a clear and easily understandable language that could be easily discerned by all of those employed regardless of level of education, vocabulary, grasp of syntax, etc. The manual was designed to serve a multi-purpose role as both a quick reference book for those on shift, a training supplement and refresher course for those lacking the experience to adequately perform on the job, a statement of purpose to help employees understand their role in the larger Dairy environment, a how-to guide for what to do in an emergency, and a review of the procedures

currently performed by Cal Poly for revision if necessary. While, as mentioned above, the majority of the processes required little to no revision, the goals outlined for the manual to serve its other functions were by and large met.

Initially, a flow chart was written out describing all processes, sub processes, setups and steps critical to milking, maintenance, and running of the Cal Poly milking parlor. Following the establishment of all processes necessary for documentation, written descriptions of all critical control points, standard operating procedures, etc. were spelled out explicitly in written form. Descriptions were written in some detail for those seeking background information, with brief summaries of each step provided in italics as captioning for photographs which would be submitted as visual representations at a later time. The research conducted for the literature review, the author's previous experience as a milker at the dairy, the counsel of the milking section of the dairy staff and the farm manager, and the previously written Cal Poly dairy SOP were all consulted with regard to developing the layout and content of the above list. All consulted agreed that a key aspect lacking in the previous SOP was a detailed description of how to perform setup and milking procedures (steps were listed which functioned effectively in cases where milkers knew how to perform said tasks, but the SOP was of little use to those who had not been adequately trained in how to perform the tasks outlined). All consulted also agreed that the most useful addition to an updated procedure would be photographic displays and diagrams showing all processes in a visual representation, as this would make it easier to understand what was being outlined in the written procedure for those with a limited understanding of terminology and nomenclature associated with locations and equipment in the milking parlor.

Once the list had been developed and formatted to display all steps of the processes and sub-processes performed daily to run the Cal Poly milking parlor, extensive photographic

documentation of the parlor and its various setups, procedures, critical control points, equipment, locations, diagrams, etc. was conducted. Using a Cannon Powershot SD1400IS digital camera and Minolta SLR X-370 film camera, all processes and components listed above were photographed during their setup and execution Processes that were not conducted during the duration of the documentation period such as tank washing were represented by photos which illustrated all necessary components and how to use them in the context of the task performed. Photos were taken in color, and all on the same shift for consistency. The one problematic incident arising from photographing the parlor setup and teardown procedures resulted from the fact that the milk truck only picks up milk from the farm at an unspecified and unset hour Wednesday and Friday mornings, limiting the ability of the event to be photographed. Likewise with the setup of CIP tank systems and configuration of the top pipe with regards to milking, all of which occurred at times that made photographic documentation either difficult or not at all possible. These events were portrayed by representative photos in the final layout instead, though the actual event had not been photographed. Once all photographs had been processed and developed they were inserted (or scanned into the computer and inserted in the case of the film prints) into the document which had been formatted as a Microsoft word document.

Organization of the document was formed in a least to most specific information format. The document was initially laid out with all emergency information listed first, but this was later integrated into its own subheadings in the first section of the document. General information on mission statement, job description, clocking in, milking hygiene, appropriate attire, etc. were included in this section. The ensuing sections dealt with the topics of setup, milking, and teardown, and all needed sub-processes to facilitate this. The manual was developed not only as a guide to milking, but as a guide to complete all maintenance procedures and operations

associated with the dairy parlor such as washing tanks, which may not be directly necessary for milking but nonetheless still falls under the milkers' jurisdiction. The manual was conceived as a how-to guide for all parlor functions. Initially, a training video was also set to be made and included, and a survey of dairy farms conducted to ascertain which practices were most widespread, accepted and effective in the industry. While the survey was conducted, the information ascertained from it was too vague to draw any conclusive statements from. Likewise, while a training video was shot, it proved an impractical option to assemble in any kind of quality presentation that would be effective on a low budget, and hence the initial idea was struck from the project. Alternatively, however, the signage devised with the initial conception of the project was designed, produced and implemented. This signage was created using photos that were purpose-taken at the farm for reference, and were printed at the Cal Poly Student Print Center of Kennedy Library (see appendix B). Before printing they were submitted to the staff of the milking section for evaluation of usefulness and effectiveness, and following slight revisions to the typeface and image proportions, they were submitted for approval to the farm's manager. Following his approval, the signs were printed and posted in the parlor. The sheets that were printed were signs denoting the proper steps to take during the milking procedure itself (pre-dipping, stripping, wiping, etc.), a sign noting that the switch on the CIP attachment point should be left up during milking and down during CIP cycling, a sign denoting the caps that should be sealed in the milk lines, a sign to remove the pipe from the top of the tank upon completion of milking, a sign warning that the crowd gate should be lowered only after visual confirmation that there were no cattle or employees beneath it, a sign stating that float balls should be in place before milking was initiated, assign stating that the crowd gate would not cease rearward movement until set to forward, and a sign that stated the proper direction of milk

flow levers during washing and milking cycles. These signs were designed with the intention of alleviating future confusion during setup and teardown on the part of inexperienced milkers, and to remind more experienced milkers to check all points thoroughly to avoid accidents that would result in adulteration, contamination or spillage of milk. Signs that were for purposes of instruction were labeled "Advisory", those of a more urgent nature put in place for safety purposes were headed "Warning."

The manual itself also went through a process of revision that began with its submission to veteran members of the milking section for evaluation. Following implementation and revision to some of the text based on their input, it was submitted to the farm manager for revision. Here, two images were revised and some of the text re-worded to clarify explicitly its meaning. Following this it was submitted to the project supervisor for evaluation a final time. In its final state the manual was bound and submitted as appendix B of this paper (see below). Further, the project supervisor recommended that a quiz be formulated to gauge comprehension of the material provided to potential employees in the manual. A ten question quiz was then constructed, and added to the end of the training manual for use by the farm supervisor for evaluation of milkers during training sessions (see appendix B).

The project was as successful as it could be given its limitations. Given the lack of large scale budget and professional staff tasked to the project, its outcome was always slated to be somewhat rudimentary in comparison to the high budget training programs established in the farm settings of the industry. That said, the training manual was as thorough as could have been written. The shortfalls in the project were mostly the result of lack of technology. The training video might have been a powerful asset had it been successfully realized. However, given the lack of experience the project engineer had with film and the lack of editing software available,

the final product would have had negligible value at best. Upon further evaluation of the results of this project, the need to adapt the traditional training manual format to the needs of a technologically advanced workforce to maintain synergy and ease of access became apparent. If redrafted, this project would have been well implemented as a smart phone application or an internet document to allow for ease of access, portability without threat of physical damage or loss to the paper. However, these may be grander designs then are necessary. For the task at hand, namely instructing employees and providing them with an emergency reference to turn to in times of crisis or confusion, this manual serves its purpose abundantly. The signs posted in the parlor will guide future generations of milkers in the safest, most effective and efficient ways to milk, and prevent accidents or breaches of protocol that would cost the dairy time, money, and repute in its public image. A formalized written training program was created where previously none existed, and was created in a form that can be altered and updated easily as advances in technology or changes in protocol occur. This document was created with the intention of creating a living document for the instruction of Cal Poly's workers, and it will serve this function wholly.

CONCLUSION

The potential of well developed, well thought out diary milking protocols based firmly in science and modern technology instead of old world practices and uninformed misconceptions represents the future of the dairy production industry. Developing efficient plans which communicate the dairy's management strategy, aims, policies and techniques will result in more

professional milkers, healthier cows, a stronger perception of the diary parlor and its workers by the general viewing public, and more efficient integration of the dairy parlor into the greater management scheme of the feeding and healthcare regimens of the dairy. The efficiency and understanding by milkers in the parlor that they are the core of cow care, lactation harvest, and the first line of defense in identifying ailing cows, as well as the representative "face" of the dairy they work for will result in a healthier, cleaner, safer and more profitable dairy.

Even within the scope of this project, it was clear that the potential for developing personalized management strategies that engage and appeal to parlor workers are limitless. With the widespread use of smart phones and Wi-Fi technology, the technological aspects not addressed in this project may well be the foreground of parlor management strategies in the future, to ensure that parlor standard operating procedures continue to act in a manner that produces a clean, safe, efficient and skilled work environment. In doing so the future longevity, vivacity and most important profitability of individual dairy farms and by extension the dairy industry itself will be ensured.

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APPENDIX B