Case Report # 2: A Clinical Mastitis Outbreak in Dairy Cows

Introduction

Mastitis continues to be the most costly disease to animal agriculture in the US and throughout the world[1]. The National Animal Health Monitoring System (NAHMS) Dairy 2002 survey found clinical mastitis was reported in 14.7% of the cows during 2001. The range between small (<100 cows), medium (100 – 499 cows), and large herds (500 or more cows) was 13.6% for medium size herds to 15.6% for the small herds with large herds falling in between. The cost of a case of clinical mastitis was estimated to be $102 - $162, with the majority of the cost due to lost milk production[2].

Mastitis is also a significant contributor to death loss in dairy cows. The NAHMS Dairy 2002 survey found annual death loss in dairy herds to be 4.8% with 17.1% of that being attributed to mastitis. Death attributed to mastitis was the second most common cause behind calving problems. The survey also compared death loss between the Dairy 1996 survey and the Dairy 2002 surveys. While it looked like death loss attributed to mastitis increased only slightly on a percentage basis from 1996 to 2002 (16.3% vs. 17.1%), overall percent death loss increased from 3.8% in 1996 to 4.8% in 2002[3]. This indicates that the total number of animals dying annually continues to increase despite the amount of time and money spent on mastitis prevention.

An indicator that mastitis is becoming more of a problem in the US is the increasing bulk tank somatic cell count (SCC) over the last few years. The USDA annually monitors bulk tank SCC from four of its eleven orders, which represent 49% of the total milk pounds shipped. From 1997 through 2001, there was an increase in bulk tank SCC from 307,000 to 319,000 in 18,840 herds, which had milk shipments every month during the five-year period[4].

Bacteria responsible for causing mastitis are divided into contagious pathogens or environmental pathogens. Contagious mastitis pathogens are organisms that are spread from an infected cow to a non-infected cow during the milking process. The major contagious mastitis pathogens are *Staphylococcus aureus, Streptococcus agalactiae,* and *Mycoplasma sp.,* primarily *M. bovis.* The major environmental pathogens include *Streptococcus dysgalactiae, Streptococcus uberis,* and *Escherichia coli.*

Even though environmental mastitis has become more prevalent compared to contagious mastitis, clinical mastitis and herd problems caused by the contagious pathogens still occur on a regular basis. Knowing what pathogens are causing mastitis problems in a herd is essential because mastitis control measures are different for contagious versus environmental mastitis. Contagious mastitis control typically focuses on milking practices and machine function, while environmental mastitis control primarily focuses on the cow and her environment. However, the milking system can be a contributor to the overall problem in many environmental mastitis situations.

Milking machines contribute to mastitis outbreaks by increasing the exposure to pathogens or by reducing disease resistance. There are four ways in which this happens:[5]

1. Bacteria are transferred from cow to cow when cows are milked without proper teat sanitation allowing contamination of the milking unit. These bacteria can then be transferred to cows milked later in the milking shift.

2. Pathogens can penetrate the teat when a liner slip causes a vacuum fluctuation within the milking unit propelling bacteria directly into the teat sinus.
3. Overmilking has been shown to be a contributor to the development of hyperkeratosis of the teat end. When hyperkeratosis occurs, bacterial colonization occurs allowing for increased exposure of bacteria to the teat end. Additionally, teat ends affected by hyperkeratosis are difficult to properly sanitize prior to unit attachment.
4. Teat end hyperkeratosis affects the ability of the teat sphincter to properly close. A teat end that cannot close completely will be more susceptible to bacterial penetration. In addition, local pain may lead to neurohormonal responses, which may suppress immune function and increase the likelihood of disease.

In order to minimize the milking machine's contribution to the development of mastitis, the National Mastitis Council has developed a set of procedures and guidelines for evaluating vacuum levels and airflow in milking systems[6]. The objectives of a standardized system evaluation are to minimize vacuum differences throughout the system and optimize the efficiency of vacuum regulation. While the purpose of the NMC publication is to develop a standard set of milking machine evaluation procedures, it does not deal with overmilking and milker activities, which are equally important in minimizing mastitis spread in milking facilities.

Overmilking can be defined as a period of time in which the teat end is exposed to full system vacuum during low milk flow (<1 kg/min). Overmilking can occur at the beginning and end of each milking and contribute to the development teat end lesions, primarily teat end hyperkeratosis[7].

Hyperkeratosis is excessive keratin growth and is a normal physiological response to forces applied to teat skin during milking. The response can occur as a response to a milking machine, a hand milker, or a suckling calf. Histological examinations confirm that teat end hyperkeratosis is a localized hyperplasia of the stratum corneum or the stratum corneum and the stratum granulosum[7]. Teat end hyperkeratosis is influenced by climate, seasonal and environmental conditions, milking management, herd milk production level and genetics of the herd[8]. Experience by the author and others have shown that teat end hyperkeratosis is more common in high producing herds during the winter months[7].

A group of mastitis researchers have recently put forth a scoring system for teat condition and the affect of these lesions on intramammary infections. With regard to hyperkeratosis, their scoring system classifies teat ends as no ring, smooth or slightly rough, rough, or very rough[9]. Evaluations in herds with teat end hyperkeratosis have found that teats classified as having smooth rings were less likely to develop clinical mastitis, while teats classified as rough or very rough were more likely to develop mastitis[10].

Reducing hyperkeratosis has many components. While it is impossible to alleviate the contribution of cold weather and genetics of the herd, minimizing overmilking and maintaining skin in good condition are essential.

Overmilking at the beginning of milking occurs when the milking unit is attached to an improperly stimulated teat. Proper teat stimulation as part of a good udder preparation routine will result in immediate rapid milk flow when the milking unit is attached. Without proper teat stimulation, milk flow will begin once the unit is attached, but the flow of milk ends once the teat and gland cisterns are evacuated. After the teat cistern is empty, no further milk flow will occur until oxytocin has reached the udder resulting in milk letdown from stimulation of the myo-epithelial cells.

Overmilking at the end of milking occurs once milk flow falls below 1 kg/min and the milking unit remains attached. This occurs when automatic detachers are set with end of milk points set to milk cows very dry or in the absence of automatic detachers in which milkers are not properly trained to remove milking units.

Over the last ten years, there has been tremendous focus by milk quality professionals to reduce the amount of overmilking in facilities with automatic detachers[7, 11, 12, 13, 14, 15]. The focus of these individuals has been to establish a level of milk flow for unit removal at which there will be no increase in mastitis, no reduction in milk production, and teat end hyperkeratosis will be minimized. Prior to looking at increasing end of milking flow rates, a cow was properly milked when milk flow dropped to 200 g/min[11]. Two separate controlled studies have looked at differences in milk harvest and machine on-time when automatic detachers were set at low and high flow rates[11, 15]. Each study had different definition for low and high flow rates. Additionally, one of the studies looked at SCC, clinical and sub-clinical mastitis rates, and teat end hyperkeratosis[11]. The results of both trials showed a decrease in total unit on time between 0.17 – 0.52 minutes in the high flow groups with no decrease in total milk production. There was no difference in milk quality parameters, but a significant reduction in teat end lesions occurred in the high flow rate group.

Current recommendations for end of milking flow rates are 0.68 – 1.0 kg/min for herds milk 2x/day and 0.9 – 1.1 kg/min for 3x/day herds. End of milking delay should be set as low as possible, often times as low as 0 or 1 second[a]. Depending upon age and manufacturer of the detacher, there is a fair amount of variation in the ability of a detacher to achieve these levels.

A test has been developed to evaluate completeness of milk out by stripping teats into a measuring cup after the automatic detacher has removed the milking unit. Cows are considered completely milked out if there is less than 250 – 500 mls left in the udder after unit removal.

Clinical Report

A 250-cow dairy contacted the author in mid-December 2002 with a concern of increasing number of cows with clinical mastitis and bulk tank SCC. Through the first twenty days of December, the dairy had already experienced more cases of mastitis than the previous month. The DHIA average SCC done earlier in December was 404,000 cells/ml, up from 267,000 and 301,000 cells/ml for October and November respectively. Table 1 shows the breakdown of SCC and clinical cases from September 2002 through March 2003. In addition, the dairy had recently been notified by their milk cooperative that their bulk tank had cultured positive for *Mycoplasma sp.* on a monthly screen.

The dairy consisted of approximately equal numbers of Holstein and Brown Swiss cows. Production data for the herd were: 10,137 kg of milk on a 305 day mature equivalent (ME), 3.7% fat and 3.0% protein. Current daily herd production data was 33.5

Table 1. Mastitis and SCC parameters for the herd from September 2002 through March 2003.

	# of Clinical mastitis cases	DHIA Average SCC (x 1000)	Bulk tank average SCC (x 1000)	Percent New Infections*
9/2002	9	277	255	11
10/2002	7	267	224	11
11/2002	7	301	245	11
12/2002	12	404	328	13
1/2003	14	338	284	10
2/2003	10	312	245	9
3/2003	10	195	205	7

*Percent new infections are figured by taking the number of cows that had an SCC<200 for the previous month and an SCC>200 for the current month as a percentage of all cows that had an SCC for both months.

kg of milk per day, 34 kg of management level milk with average days in milk of 178. One ration was fed to all lactating cows in the herd. The cows were milked twice per day. The cows were housed in five dry lot corrals of approximately fifty cows per corral.

The dairy manager consulted with the author via a telephone conversation about the concerns of increasing bulk tank SCC, clinical cases of mastitis and the *Mycoplasma sp.* positive bulk tank. This was the first time this dairy had *Mycoplasma sp.* isolated from their bulk tank and finding the source of the *Mycoplasma sp* was the primary concern. It has been the experience of the author and others that approximately 50% of bulk tanks will be negative on repeat cultures with no action taken[16]. During the telephone consultation, the following diagnostic approach was formulated.

1. Due to the fact that *Mycoplasma sp.* often spontaneously cure from bulk tanks, the bulk tank culture should be repeated to confirm the presence of *Mycoplasma sp.*
2. The *Mycoplasma sp.* isolate from the laboratory at the milk cooperative would be forwarded to a diagnostic laboratory for speciation. This was done to determine whether the isolate was a mastitis causing strain or a contaminant.
3. When time permitted within the next week, string samples from each pen should be collected and frozen. If the second bulk tank culture confirmed the presence of *Mycoplasma sp.,* the string samples should be submitted for *Mycoplasma sp.* isolation. Should any of the string samples be positive, all cows within the pen should be individually sampled for *Mycoplasma sp.* It was recommended that all pen changes needed to be

done before the string samples were taken. No cows were to be moved until the results of the string samples were obtained. If any strings were positive, no cows should be moved in or out of the positive pens until the individual samples results were obtained.

4. All new cases of mastitis should be cultured both aerobically on blood agar and for *Mycoplasma sp.*
5. A farm visit was scheduled later in the week to evaluate the milking system, milking procedures, and overall herd hygiene.

The farm visit was conducted on December 27, 2002. The first component that was evaluated during the farm visit was corral conditions. The corrals were muddier than normal for that dairy, but this was due to recent rainfall. In general, cow cleanliness was very good considering corral conditions.

The milking system was evaluated using the protocol proposed by the NMC[6]. The milking parlor was a double 6-herringbone design with each stall equipped with a milk meter and an automatic detacher. The system had a 10.1 metric horsepower vacuum pump and a 7.62 cm milk line mounted in a low line design with one stainless steel receiver. Figure 1 shows a diagram of the milking system. Table 2 shows the results and suggested guidelines for each measurement from the equipment evaluation.

System vacuum differences were evaluated at the receiver, regulator, pump inlet, end of the pulsation line, and the farm vacuum gauge. All vacuum levels were within suggested parameters of two kilopascals (kPa) between the vacuum pump and the receiver and less than 0.7 kPa between the receiver and the regulator[6]. One concern, however was that every time the receiver vacuum was measured, it seemed to fluctuate

Figure 1. Diagram of the milking system on the initial visit.

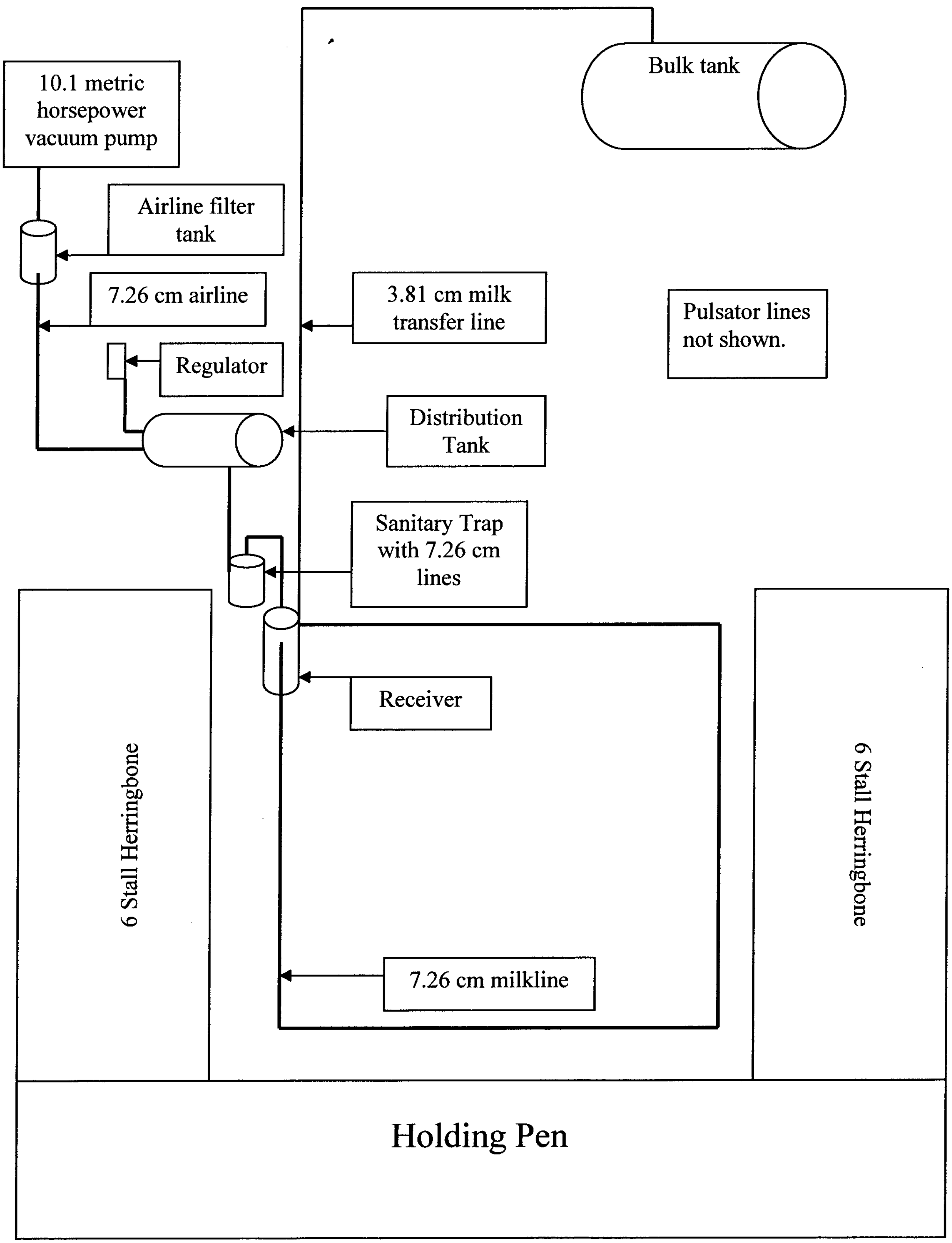

Table 2. Results from the milking system evaluation performed on 12/27/02.

1. System Vacuum Differences	Vacuum (in kPa*) at:				
	Receiver	Regulator	Vacuum Pump	Pulsator Airline	Farm Vacuum Gauge
1a) Teat Cups Plugged**	43.6	43.9	44.6	43.6	42.6
1b) One milking unit open** (Mimic unit fall off)	41.6	41.9			

*kPa = kilopascals

**The difference in vacuum level between the vacuum pump and the receiver in 1a should not exceed 2.0 kPa. The difference in vacuum level between receiver and regulator in 1a and 1b should not exceed 0.7 kPa.

2. Airflow Measurements				
Type of Measurement	As found			Guideline
2a) Effective reserve (Liter/min) (Measured at 2.0 kPa below Receiver vacuum)	1585	2c) Regulation Efficiency ER/MR = 76.7%	2d) Vacuum change at Regulator 1.7 kPa	2c) At least 90% regulation efficiency. 2d) At least 1.35 kPa.
2b) Manual reserve (Measured at 2.0 kPa below Receiver vacuum)	2066			

3. Air Used by Components (Measured at receiver vacuum)	AFM Reading (L/min)	Air Used	Air used/unit	Guideline
3a) Air Flow Meter (AFM) Reading (System at normal operating vacuum and regulator disconnected)	1868			
3b) Pulsators disconnected	2122	254	21	Typically 21 – 42 L/min per unit.
3c) Milking units disconnected	2179	57	4.8	Typically 8.5 – 14 L/min per unit.
3d) Other -Meters	Meters not tested			
				3 f) Pump Inlet vacuum = 45 kPa

Table 2 (cont.). Results from the milking system evaluation performed on 12/27/02.

4. Vacuum pump(s)	Pump 1				
4a) Capacity at 50.7 kPa	Not Done				
4b) Capacity at pump inlet vacuum (Vacuum at pump inlet (Step 3f)=45 kPa)	3396 L/min				

5. System Leakage	As found	Percent of 4b		Guideline
(4b minus AFM reading after 3c)	1217	35%		Maximum of 10% pump capacity at pump inlet vacuum.

6. Pulsation Tests (Done with all teat cups plugged)	Front	Back		Guideline
Ratio	60:40	60:40		
A Phase (%)	12	12		
B Phase (%)	49	49		At least 30%.
C Phase (%)	12	12		
D Phase (%)	27	27		At least 15% or 150 msec.
Rate	52	52		
The above parameters for the pulsators were an average of all twelve pulsators. All twelve pulsators were within normal parameters so the actual number for each pulsator was not included.				

7. Dynamic Tests			Guideline
7a) Vacuum fluctuation in milkline while attaching units.	2.0 - 2.7		Less than 2 kPa desirable.
7b) Average peak flow claw vacuum (average of 10 cows)	41		35.5 – 42.25 kPa

from the previous measurement by 0.3 – 0.7 kPa, thus eluding to some system vacuum instability.

Regulator efficiency was determined by measuring the effective and manual reserve of the system. Effective and manual reserves were measured by placing an airflow meter in a test lid on top of the receiver. Effective reserve was determined by opening the air flow meter to allow air to flow into the system until receiver vacuum is decreased two kPa (41.6 kPa in this case). The amount of air needed to decrease the system vacuum to 41.6 kPa was 1585 liters/min (L/min). The required effective reserve for a milking system with twelve milking units is 1330 L/min (990 L/min + 28.3 L/min per milking unit (28.3 * 12)).

The manual reserve was measured by removing the regulator from the system and capping the mounting bracket so no air could enter the system at that point. The system vacuum was adjusted by the air flow meter until it reached 41.6 kPa. The manual reserve was determined to be 2066 L/min. The regulator efficiency was determined to be 76.7% by dividing the effective reserve by the manual reserve, which was below the suggested 90%. The vacuum level was also measured at the regulator when the vacuum was decreased to 41.6 kPa to determine how much of the vacuum change the regulator was detecting. This was done to test if regulator location was correct and whether the vacuum supply lines were of adequate size. The vacuum change at the regulator was determined to be 1.7 kPa. National Mastitis Council guidelines suggest that the regulator should detect at least 1.35 kPa of the 2 kPa change[6].

Air used by the components was measured by leaving the regulator disconnected and turning off components one at a time. Vacuum levels were adjusted with the air flow meter. After each component was disconnected, the vacuum adjusted back to the receiver vacuum found in 1a of Table 2. Air used by the pulsators and milking units were within normal limits. The air used by the meters was not tested because devices to plug the connections between the meters and the milk line were not available. However, there was air leaking from the meters that could be detected audibly. The source of the air leakage, whether it was vacuum from the meters or pressurized air used to control the vacuum shut offs, was not determined.

Air leakage was measured by comparing the airflow at the receiver versus what was being produced at the vacuum pump inlet at normal system vacuum. There was 2179 L/min present at the receiver after all components, with the exception of the meters, were disconnected. When the air flow meter was placed in the pump inlet, the pump was found to be producing 3396 L/min. System leakage was determined to be 35% by dividing the airflow at the receiver by the airflow at the pump inlet. National Mastitis Council guidelines suggest that system leakage should be no more than ten percent[6].

All of the components of the milking system were placed in normal operating position and the vacuum pump was re-started. A flow simulator[b] was then assembled in one of the milk stalls to determine claw vacuum levels at simulated milk flow rates of four and six L/min. These flow rates were selected because four L/min is the desired average milk flow rate throughout the entire milking and six L/min is the desired average peak milk flow rate during milking. The results of the flow simulator test were used to assess udder preparation routines during the milking time evaluation and to make recommendations for desired vacuum levels.

Water was placed in the flow simulator and the flow meter was set at four liters per minute. A vacuum recorder[c] was used to measure claw vacuum by placing a twelve-gauge needle connected to the vacuum recorder into the milk claw. Average claw vacuum at four L/min was determined to be 40.9 kPa. Claw vacuum was also measured at a flow of 6 liters per minute and determined to be 39.2 kPa.

The pulsators were then tested with the teat cups plugged with teat plugs to simulate normal milking conditions. All pulsators were found to be operating within normal guidelines[6]. The only change suggested with the pulsation system was to increase the pulsation rate from 52 to 60 beats per minute in order to speed up milking.

A milking time evaluation was performed. Milk line vacuum was measured during unit attachment and during milking. Milk line vacuum fluctuated between 2 and 2.7 kPa during unit attachment. Recommended guidelines suggest that vacuum should fluctuate no more than two kPa[6]. Experience by the author has shown this brand of regulator to maintain system vacuum with much less fluctuation.

Claw vacuums were measured on ten cows during peak milk flow by placing a twelve-gauge needle attached to a vacuum recorder into the bowl of the milking unit. Time at peak milk flow was estimated to occur between the first and second minute of milking. The measurements obtained on the ten cows were averaged and determined to be 41 kPa. Comparing the measurements obtained from the flow simulator lead us to estimate that peak milk flow was approximately four kg/minute.

While the claw vacuums were being measured, milker udder preparation technique was evaluated. The dairy used one milker per shift. The milker was prepping all of the cows on one side of the parlor as one group. When cows filled a side of the parlor, the milker would strip three to four strips of milk from each teat and pre-dip the teats with 0.5% iodine pre-dip. After the pre-dip was applied to the first cow, the milker would repeat the procedure on the next five cows. When all six cows were stripped and pre-dipped, he would return to the first cow and dry the teats with a cloth towel. He would then attach and align the milking unit to the cow. The drying and attaching procedures were repeated for the remaining cows. This routine was taking two minutes or longer from the time of first udder stimulation to unit attachment. When the automatic detacher removed the milking unit, the milker would apply one percent iodine post-dip to all teats before releasing the cows from the parlor to return to the corral.

While observing the milking, it was noted that there were between 10 – 20% of the cows experiencing liner slips allowing air to enter the milking claw. Recommendations for liner slips are to have less than five percent of the cows to experience a liner slip during milking[a]. Further observation allowed the investigators to determine that the majority of the liner slips occurred at the end of the milking when milk flow was low. This was facilitated by cow movement, characterized by stepping and kicking at the milking unit, apparently in response to pain caused by overmilking.

Completeness of milk-out was evaluated by hand stripping ten cows into a measuring cup after the automatic detacher removed the milking unit. The majority of the cows had less than ten mls of milk left in their udders and all ten cows had less than fifty mls left.

Teat end condition was evaluated on 36 cows while the parlor evaluation was performed. Of those 36, approximately 35 – 50% of the cows had at least one teat with rough or very rough hyperkeratosis classifications.

The final step of the parlor evaluation was to determine the flow rate and delay phase for the automatic detachers for unit removal and review the milking time summary. The milk meters were attached to a Bou-Matic Agri-Comp 2050 computer network system[d] that monitored milk flow and summarized the information for the herd. The Bou-Matic computer system was attached to the herd health computer program[e], which printed a summary of each milking at the conclusion of the milking shift. The flow rate for initiation of unit removal was 0.64 kg/min with a three second delay period. Summaries for the last fourteen milkings were evaluated and it was determined that average peak flow was approximately 3.5 kg/min with an average flow for the entire milking was 2.5 kg/min. Milk harvested in the first two minutes was 5.4 kg.

The dairy manager had culture results for eleven clinical mastitis cases. The results showed three of the samples were *E. coli;* three were *Streptococcus sp.*; one was *Arcanomyces pyogenes* and three were no growth. The bulk tank culture that was done to confirm the presence of *Mycoplasma sp.* was negative so no further string samples were completed. The results from the typing of the *Mycoplasma sp.* from the first bulk tank were never reported to the dairy manager.

At the conclusion of the farm visit, the major areas of concern were poor vacuum stability due to an improperly functioning regulator and the amount of teat end hyperkeratosis. Previous clinical experience has shown that teat end hyperkeratosis problems occur during cold weather especially when overmilking is occurring. In those situations, teat end condition was improved by reducing both overmilking and total unit on time.

The following recommendations were made:

1. Remove and clean the regulator and then replace it back it into the system to improve the efficiency. Double-check the system vacuum after placing it back in the system.
2. Repair the air leaks on the meters to reduce system air loss.
3. Increase the pulsator rate from 52 to 60 beats per minute to milk cows faster and reduce unit on time.
4. Increase system vacuum 0.84 kPa at weekly intervals until the system vacuum reaches approximately 46.5 kPa. This will allow cows to be milked out faster and reduce unit on time.
5. Decrease the delay phase for the automatic detachers from three seconds to one second as soon as possible. In approximately one week, start increasing the end of milking flow rate approximately 0.05 – 0.1 kg/min at two to four week intervals. This will cause the automatic detachers to remove the milking units sooner and reduce overmilking. If there is a concern about cows being completely milked out, ten to fifteen cows should be stripped out into a measuring cup. If there is less than 250 mls left in the udder after the milking unit is removed, the cow is completely milked out.
6. The milking system should be re-tested as soon as the repairs are made and a new visit can be scheduled.
7. Adjust the milker's udder preparation routine slightly. It was suggested that the milker should only prepare udders in groups of three. This should allow the milker to attach units within 60 – 90 seconds from the beginning

of the routine for each cow. In addition, the drying procedure should be improved by making sure the milkers are drying the entire teat including the teat end instead of just the barrel of the teat.

The suggested repairs were made and the follow up visit was conducted on January 16, 2003. Table 3 shows the results and suggested guidelines for each measurement from that visit. After the first five steps of the system evaluation, it was decided to try to correct the regulator inefficiency and air leakage problems. This decision was facilitated by the fact that a service technician was on the dairy at the time the system evaluation was being done.

The first repair to be made was to move the location of the regulator. This decision was made because the vacuum change seen by the regulator in step 2d of Table 3 was 1.0 kPa which was less than the suggested 1.35 kPa guideline. Since the regulator was not seeing the suggested vacuum change, the regulator location is incorrect or the vacuum supply lines were not plumbed sufficiently. It was decided to move the regulator from the vacuum pump side of the distribution tank (Figure 1) to the vacuum supply line directly above the trap.

While the service technician was moving the location of the regulator, the source of the vacuum leak was investigated. The author had a phone consultation with a veterinarian who specializes in milking equipment prior to the second farm visit who suggested looking at the airline filter tank as a source of the leak[a]. When the lid of the airline filter tank was removed, it was discovered that the gasket that helps prevent air leakage around the lid was deteriorated. Since a new gasket was not immediately available, the lid was taped shut using duct tape.

Table 3. Results from the milking system evaluation performed on 1/16/03.

1. System Vacuum Differences	Vacuum (in kPa*) at:				
	Receiver	Regulator	Vacuum Pump	Pulsator Airline	Farm Vacuum Gauge
1a) Teat Cups Plugged**	46.5	46.6	47.3	46.6	45.6
1b) One milking unit open** (Mimic unit fall off)	45.0	45.1			

*kPa = kilopascals

**The difference in vacuum level between the vacuum pump and the receiver in 1a should not exceed 2.0 kPa. The difference in vacuum level between receiver and regulator in 1a and 1b should not exceed 0.7 kPa.

2. Airflow Measurements				
Type of Measurement	As found			Guideline
2a) Effective reserve (Liter/min) (Measured at 2.0 kPa below Receiver vacuum)	2150	2c) Regulation Efficiency ER/MR = 82.6%	2d) Vacuum change at Regulator 1.0 kPa	2c) At least 90% regulation efficiency. 2d) At least 1.35 kPa.
2b) Manual reserve (Measured at 2.0 kPa below Receiver vacuum)	2603			

3. Air Used by Components (Measured at receiver vacuum)	AFM Reading (L/min)	Air Used	Air used/unit	Guideline
3a) Air Flow Meter (AFM) Reading (System at normal operating vacuum and regulator disconnected)	2406			
3b) Pulsators disconnected	2717	311	26	Typically 21 – 42 L/min per unit.
3c) Milking units disconnected	2773	56	4.7	Typically 8.5 – 14 L/min per unit.
3d) Other -Meters	2830	57	4.8	
				3 f) Pump Inlet vacuum = 47.3 kPa

Table 3 (cont.). Results from the milking system evaluation performed on 1/16/03.

4. Vacuum pump(s)	Pump 1				
4a) Capacity at 50.7 kPa	Not Done				
4b) Capacity at pump inlet vacuum (Vacuum at pump inlet (Step 3f)=47.3 kPa)	3283 L/min				

5. System Leakage	As found	Percent of 4b		Guideline
(4b minus AFM reading after 3c)	453	14%		Maximum of 10% pump capacity at pump inlet vacuum.

Table 4 shows the results from the portions of the system evaluation that were repeated after the repairs were made. The repairs made while on the dairy corrected the problems with regulator function and air leakage. While the claw vacuums were being measured, the milker's routine was again evaluated. The dairy management had instituted the suggested changes and the milkers appeared to be doing the routine very well.

The graphs from the milk cooperative field man's pulsator evaluation were evaluated to determine whether there was enough time in the D-phase (rest phase) of the pulsation cycle. All pulsator graphs had between 200 and 210 msec in the D-phase.

The final adjustment made that day was to increase the end of milking flow rate for initiation of unit removal by the automatic detachers from 0.64 kg to 0.71 kg. The desired end point for the flow rate was 0.88 – 1.0 kg/min.

Goals were established for milk flow rates as reported by the Bou-Matic computer system. These goals were:

Average milk flow rate:	3.5 kg or greater/min
Peak milk flow rate:	4.5 or greater kg/min
Kg of milk in the first two minutes:	7.5 kg or greater

The desired result of the changes was to improve system function and to reduce the amount of unit on time. Reducing unit on time should be accomplished by improving udder preparation routines by the milkers, increasing claw vacuum, increasing pulsation rate, and removing units sooner to reduce overmilking at the end of milking.

Table 4. Results from the milking system evaluation performed on 1/16/03 after repairs were made.

2. Airflow Measurements				
Type of Measurement	As found			Guideline
2a) Effective reserve (Liter/min) (Measured at 2.0 kPa below Receiver vacuum)	2632	2c) Regulation Efficiency ER/MR = 94%	2d) Vacuum change at Regulator 1.35 kPa	2c) At least 90% regulation efficiency. 2d) At least 1.35 kPa.
2b) Manual reserve (Measured at 2.0 kPa below Receiver vacuum)	2802			

3. Air Used by Components (Measured at receiver vacuum)	AFM Reading (L/min)	Air Used	Air used/unit	Guideline
3d) All components disconnected.	3028			
				3 f) Pump Inlet vacuum = 47.3 kPa

4. Vacuum pump(s)	Pump 1				
4a) Capacity at 50.7 kPa	Not Done				
4b) Capacity at pump inlet vacuum (Vacuum at pump inlet (Step 3f)=47.3 kPa)	3283 L/min				

5. System Leakage	As found	Percent of 4b		Guideline
(4b minus AFM reading after 3c)	255	7.8%		Maximum of 10% pump capacity at pump inlet vacuum.

6. Pulsation Tests (Done with all teat cups plugged)	Front	Back		Guideline
The pulsators were not re-tested because the milk coop field man had just tested the pulsators as part of routine evaluation within the past week.				

7. Dynamic Tests			Guideline
7a) Vacuum fluctuation in milkline while attaching units.	1.4		Less than 2 kPa desirable.
7b) Average peak flow claw vacuum (average of 10 cows)	42.25		35.5 – 42.25 kPa

As can be seen by Table 1, the SCC and number of clinical mastitis cases decreased over the next two months. The dairy manager felt that teat end condition improved dramatically throughout January. Currently the dairy has the flow rate for the detachers are set at 1.0 kg/min. The parameters for milk flow rate are:

Average milk flow rate:	3.3 kg/min
Peak milk flow rate:	4.2 kg/min
Kg of milk in the first two minutes:	7.1 kg

The dairy has been able to maintain their SCC at levels less than 250,000 with the exception of July through September of 2003 when it ranged between 250,000 – 300,000.

<u>Discussion</u>

Investigating mastitis outbreaks involves looking at three major areas: 1) the cow and her environment, 2) the milking equipment, and 3) dairy personnel activities. Often times these outbreaks reveal multiple small components that need to be corrected. The previously described mastitis outbreak fits this description.

The primary problem that occurred was the development of teat end hyperkeratosis. This prevented the teat ends from being properly sanitized prior to milking and allowed bacteria easier access into the mammary gland because of poor teat sphincter integrity.

Teat end hyperkeratosis develops more rapidly during cold weather. Hyperkeratosis develops more commonly when milking machines are allowed to milk cows at flow rates less 1 kg/min. This period of low flow rate can occur both at the beginning of milking with inadequate udder preparation and at the end of milking by not removing the milking units rapidly enough.

Several papers have been published within the last ten years declaring relationships between wetter automatic detacher settings and improved parlor throughput and teat end conditions[7, 11, 12, 13, 14, 15]. In the current case report, the dairy had automatic detachers with a flow rate setting of 0.64 kg/min and a three second delay. Gradually increasing the flow rate to 1.0 kg/min with a one second delay resulted in an improvement in milk flow rate and teat end condition.

Even though environmental mastitis occurs outside of the milking parlor, equipment malfunction may play a role in mastitis outbreaks. Two equipment evaluations were done on the milking system by the author. The first evaluation determined that the regulator efficiency was below recommended levels. A comparison of the vacuum change at the regulator and the receiver determined that the regulator location and vacuum line size was not a problem and that the regulator was most likely dirty. As noted in the case report, when the vacuum gauge was attached to the receiver, receiver vacuum level changed from the previous measurement. It was felt that the dirty regulator was causing this condition.

During the second evaluation, the regulator efficiency was still below the recommended level. The difference between the first and the second evaluation was that the vacuum change that the regulator was detecting was only 1.0 kPa. National Mastitis Council recommendations state that the regulator should detect at least 1.35 kPa of the 2 kPa change that occurs at the receiver. The dirty regulator most likely deceived the author on the first evaluation. Therefore, it was decided to re-locate the regulator to the vacuum supply pipe directly above the sanitary trap. After the regulator was re-located, regulator efficiency improved to 94%.

The approach taken by the author for milking parlor evaluations was to determine whether the milking equipment was functioning correctly but to also identify areas that will allow cows to milk out more rapidly. This will reduce the potential for the development of hyperkeratosis during cold weather conditions and could improve parlor throughput.

There were four factors identified to improve speed of milk out. These included increasing pulsation rate from 52 to 60 pulsations per minute, increasing peak flow claw vacuum by increasing system vacuum to 46.5 kPa, changing the udder preparation routine to take advantage of the cow's milk letdown, and setting the automatic detachers to remove the milking units at higher milk flow rates. As a result of these changes, average milk flow rate for the herd increased from 2.5 to 3.3 kg/min and the amount of milk harvested in the first two minutes increased from 5.4 to 7.1 kg. In addition, there was a gradual improvement in teat end condition and an improvement herd SCC.

Poor corral cleanliness was identified on the original farm visit. Although corral cleanliness is a concern regarding environmental mastitis, it has not been a problem on this dairy prior to the rains that occurred a few days before the farm visit was completed. In addition, the mastitis problems developed during a period of dry weather when corral conditions were good for the time of year.

Typical clinical case rates of mastitis in the practice area of the author will be 1.5 – 3%. The number of clinical cases as a percentage of this herd was very high. This occurred both before and after the mastitis problem occurred. Determining a case definition of clinical mastitis by the dairy found that any cow with any abnormal milk was defined as a new case of mastitis. Evaluating the records of affected cows before the outbreak found that many of the cows were indeed repeat cases of mastitis. The difference between the clinical cases of mastitis during the herd outbreak compared to prior to the outbreak was that these cases took longer to resolve.

Mastitis problems caused by *Mycoplasma sp.* are common in the dairy industry. As a control measure, a bulk tank culture was done once per month by the producer's dairy cooperative. It is the experience of the author and other dairy professionals[16] that a high percentage of *Mycoplasma sp.* bulk tanks will spontaneously cure with no action taken by the dairy. Possible scenarios for this phenomenon include laboratory error, movement of cows with clinical mastitis into the hospital pen, culling of infected cows, or dilution of bacterial numbers by reduced shedding. For that reason, the author recommends that all dairies that test positive for *Mycoplasma sp.* the first time in subsequent months should re-culture the bulk tank. In this clinical report, the re-culture was negative and the dairy has not had a bulk tank culture positive of *Mycoplasma sp.* since then.

<u>Summary</u>

A 250-cow dairy experienced a mastitis outbreak and was concerned about a recent bulk tank culture that found *Mycoplasma sp.* to be present. Re-culturing the bulk tank failed to confirm the presence of *Mycoplasma sp.*

Poor teat end condition was the primary problem noted with cold weather and overmilking considered the primary causes. Adjustments were made to the milker's

routine in order to minimize overmilking at the beginning of the milking. Additionally, automatic detacher settings were adjusted to remove milking units more rapidly and system vacuum and pulsation rate were increased thus reducing unit on time. There were also repairs made to improve regulator efficiency and to fix air leaks within the milking system.

Recommended changes resulted in improved teat end condition over time. In addition, bulk tank SCC decreased over subsequent months and the dairy has been able to maintain good udder health since the changes were made.

Endnotes

[a]Reid DA: Personal communication, Rocky Ridge Veterinary Service, SC, Hazel Green, WI, 2002.

[b]The Jenny Lynn Flow Simulator, Rocky Ridge Veterinary Service, SC, Hazel Green, WI.

[c]Agri-comp 2050, Bou-Matic LLC, Madison, WI.

[d]Dairy Comp 305, Valley Ag. Software, Tulare, CA.

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