

## EFFECTS OF MILKING VACUUM ON MILKING PERFORMANCE AND TEAT CONDITION

Douglas J. Reinemann, Misty A. Davis, Debora Costa, and Ana Carolina Rodriguez  
University of Wisconsin Milking Research and Instruction Laboratory  
Madison, Wisconsin, USA

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The effect of vacuum level on milking performance has been documented periodically in the literature. This study was undertaken to measure changes in milking performance and teat condition in response to changing vacuum level at the beginning of the current millennium with cows and milking machine settings typical of current practice; specifically, detacher settings that are more aggressive than those historically used in the field.

An observational experiment was conducted at the University of Wisconsin's Dairy Cattle Research and Instruction Facility's low-line milking parlor. About 80 cows were milked twice per day. The number of cows milked varied somewhat as cows entered and left the herd during the 14 weeks of this study. The Automatic Cluster Removers (ACR) were set to remove units if the milk flow rate was less than 0.45 kg/min (1 lb/min) for more than a five second period (delay = 5 s). The vacuum level at the regulator was changed in the manner shown in Figure 1. Regulator vacuum was reduced from 46 kPa to 42 kPa in 2 kPa increments once per week and then increased to 50 kPa in 2 kPa increments once per week. The vacuum was then reduced to 42 kPa where it remained for two weeks, then increased to 50 kPa where it remained for two weeks. Regulator vacuum was then returned to 46 kPa in 2 kPa increments, once per week. A wet test of the relationship between regulator vacuum and average claw vacuum using an ISO standard udder yielded the following relationship:

$$V_C = 0.91V_R - 1.1Q_W$$

Where:  $V_C$  = average vacuum measured in the claw (kPa)  
 $V_R$  = average vacuum measured at the regulator (kPa)  
 $Q_W$  = water flow rate through and ISO standard udder (l/min)

The following data were collected during this experiment:

Every milking for all cows:

- $Y$  = Milk yield per milking (kg); measured using milk meters in parlor

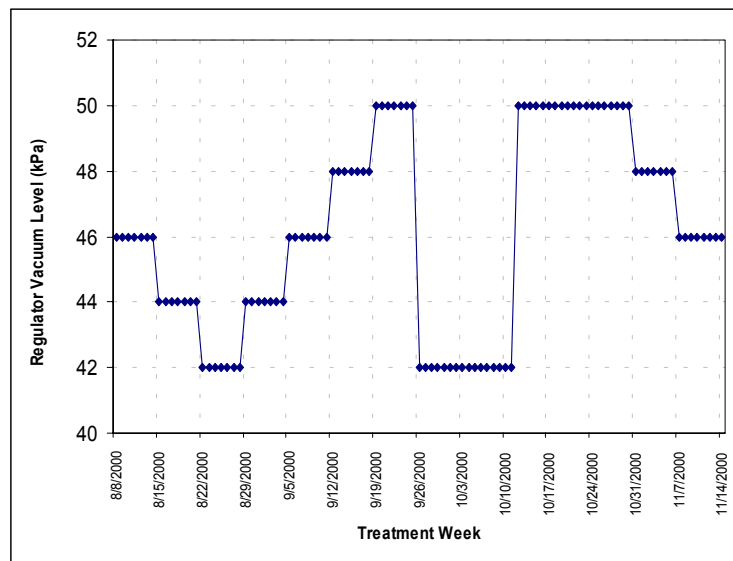


Figure 1. Vacuum Change Schedule

- D = Milking duration (min); measured as time from operator pressing attach button to machine removal by ACR
- $Q_M$  = Average milk flow rate; Y/D (kg/min)
- $Y_2$  = Milk yield during the second minute of milking; automatically recorded by milk meters in parlor

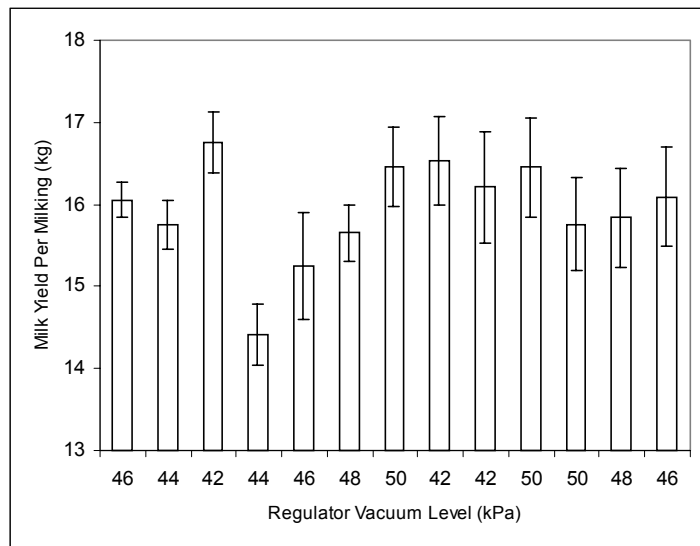
At the beginning of each treatment period for all cows:

- Teat condition scores; using the method described by Britt and Farnsworth (1996)

At the beginning and end of each treatment period for 22 cows:

- $Y_S$  = Machine strip yield (kg); milking units were reattached within 30 seconds of removal by ACR, weight was applied to milking units until milk flow was no longer visible. Machine strip yield was recorded as the difference in total yield between removal by ACR and the end of machine stripping.

Milk yield per milking is reported in Figure 2 as the average of 14 milkings for each weekly treatment interval with error bars indicating the 95% confidence interval for the estimate of the mean. A reduction in milk yield occurred in the 4<sup>th</sup> week of the study with a recovery by the 7<sup>th</sup> week of the study. This was probably due to the effects of heat stress on the herd as the reduction in milk yield occurred in late August during a period of hot weather. Previous studies have reported no significant effect of vacuum level on milk yield (Baxter et al. 1950, Gregorie et al. 1954, Caruolo et al. 1955, Hamann et al. 1993, Rasmussen and Madsen 2000).

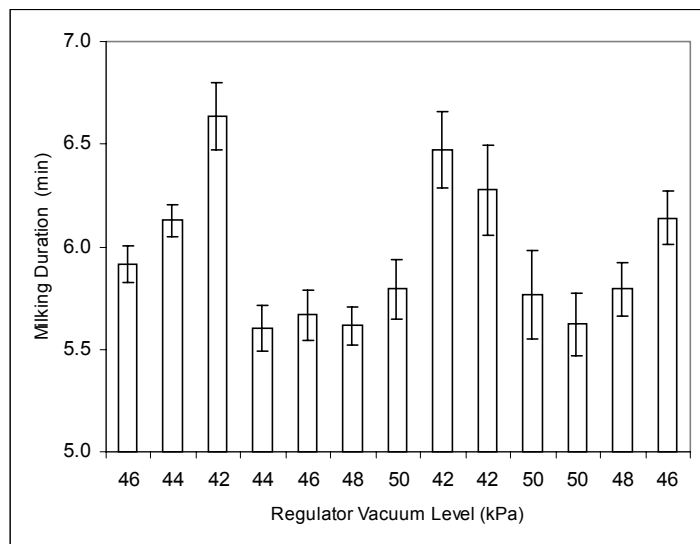


**Figure 2. Weekly average milk yield per milking.**

The weekly average milking duration and 95% confidence intervals are reported in Figure 3. Milking duration responded as expected with lower vacuum levels resulting in increased milking time. The effect of reduced milk yield on milking time is apparent in weeks four to six. Linear regression of milking duration against vacuum level and milk yield per milking for individual cows resulted in the following equation:

$$D = 5.9 - 0.067V_R + 0.18Y$$

An increase in vacuum of 2 kPa resulted in a reduction in milking duration of 0.13 minutes (8 seconds). Each



**Figure 3. Weekly average milking duration.**

additional 5 kg of milk yield resulted in an additional 0.9 minutes of milking duration. This compares favorably with the value of an additional one minute of duration for each additional five kg milk yield reported in the studies conducted in the early 1990's in England, France, and the US quoted by Mein and Reid (1996). Milk yield and vacuum level explained 30% of the variation in duration for individual cows when regressed against data for all cows. The  $R^2$  value was greatly improved by averaging the milk yield and duration for all cows during each milking; upon regression against milking duration, 85% of variation in duration was explained by yield and vacuum level.

Milking duration was regressed against milk yield using only data from tests with regulator vacuum of 46 kPa, yielding the following equation:

$$D = 2.7 + 0.19Y.$$

The vacuum level 46 kPa was chosen as typical of that used in the studies in England, France and the US performed in the early 1990's and quoted by Mein and Reid (1996). The milking duration in this study was about 0.4 minutes less than the value quoted by Mein and Reid (1996). This difference was probably due to the more aggressive ACR setting used in this study compared to typical values used in the early 1990's. This is consistent with findings of Rasmussen (1993) who reports decreases in machine-on time of 0.5 minutes when detacher settings were changed from 0.2 kg/min to 0.4 kg/min.

The weekly averages of the average milk flow rates and 95% confidence intervals for each week of the study are shown in Figure 4. Increased average flow rate was associated with increasing vacuum level, as reported previously (Smith and Petersen 1945, Baxter et al. 1950, Gregorie et al. 1954, Caruolo et al. 1955, Hamann et al. 1993 and Rasmussen and Madsen 2000). Average flow regressed against vacuum and yield per milking produced the following relationship:

$$Q_M = 0.035V_R + 0.91Y$$

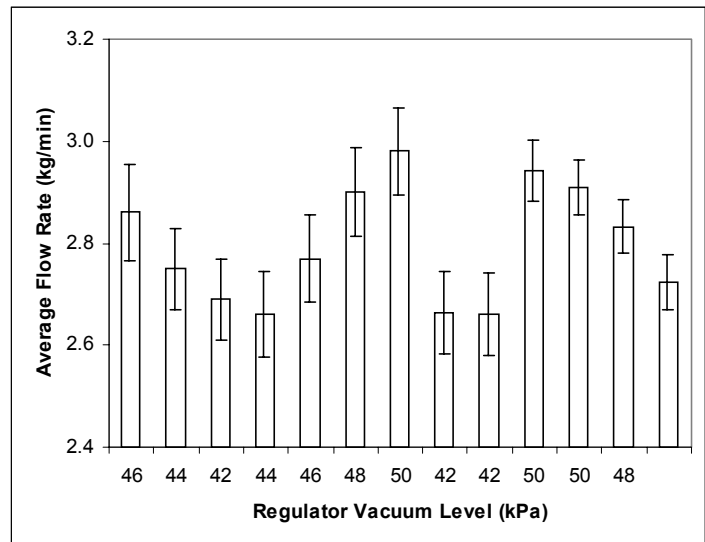


Figure 4. Weekly averages of average milk flow rate.

This study was about 0.4 minutes less than the value quoted by Mein and Reid (1996). This difference was probably due to the more aggressive ACR setting used in this study compared to typical values used in the early 1990's. This is consistent with findings of Rasmussen (1993)

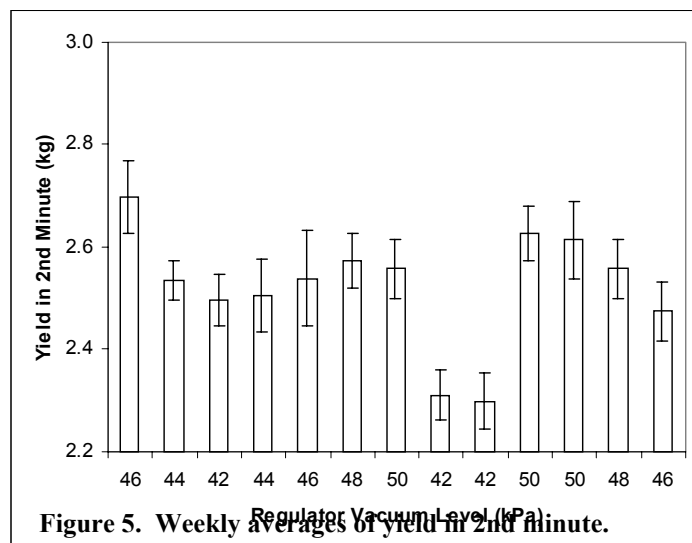


Figure 5. Weekly averages of yield in 2nd minute.

The weekly averages of yield in the 2<sup>nd</sup> minute of milking are shown in Figure 5. Peak milk flow rate, as calculated as the milk yield in the 2<sup>nd</sup> minute of milking, was lower than the average flow rate and was less responsive to changes in vacuum than average flow rate. The data for yield in the 2<sup>nd</sup> minute was truncated rather than rounded to the nearest pound by the milk recording system resulting in a reduction in the average flow rate reported during this interval. It is also speculated that true peak milk flow had not been reached for many cows by the first minute of milking because of short prep-lag times used in this single-4, side-opening parlor. These data illustrate the potential problem of using milk yield in a specified time interval as a proxy measure of peak milk flow rate.

The percentage of cows with one or more teats scoring 3 or 4 using the Britt and Farnsworth (1996) method (R or VR according to Mein et al 2001) is shown in Figure 6. The trend in number of cows with rough teats was decreasing in weeks 1-4 and increasing in weeks 6-8. There was no clear correlation between changes in teat end callosity and vacuum level. It is not possible to draw any firm conclusions, however, on the effects of vacuum level on teat condition because of the many confounding factors that were not controlled for in this study. The one-week treatment intervals may have been too short for changes in teat condition to become apparent.

It was expected that a change in teat condition score could be detected in the 2-week interval when vacuum was at 42 kPa (weeks 8 and 9) and in the 2-week interval when vacuum was at 50 kPa (weeks 10 and 11). The percentages of the 330 teats with poorer, the same, or better callosity scores for these 2-week intervals are shown in Figure 7. The percentage of teats with worse scores was somewhat higher and the number of teats with improving condition was somewhat lower for the 50 kPa treatment weeks compared with the 42 kPa treatment weeks, but the differences were not significant.

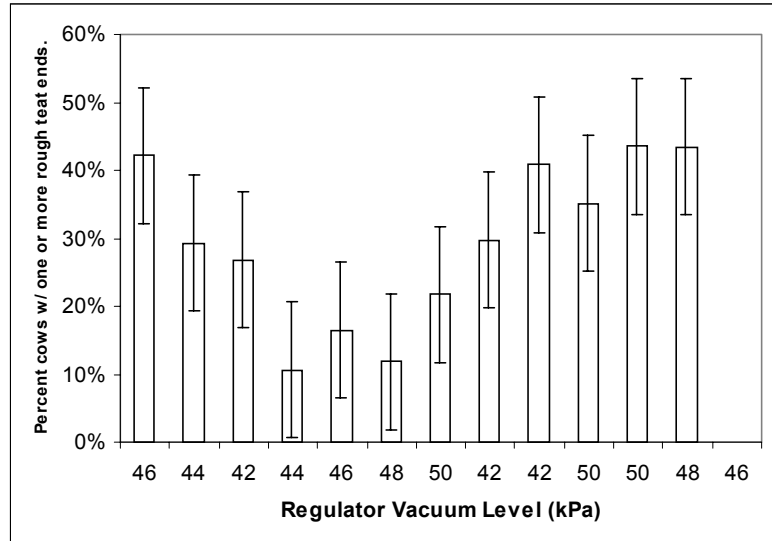


Figure 6. Percent of cows with one or more rough teat ends.

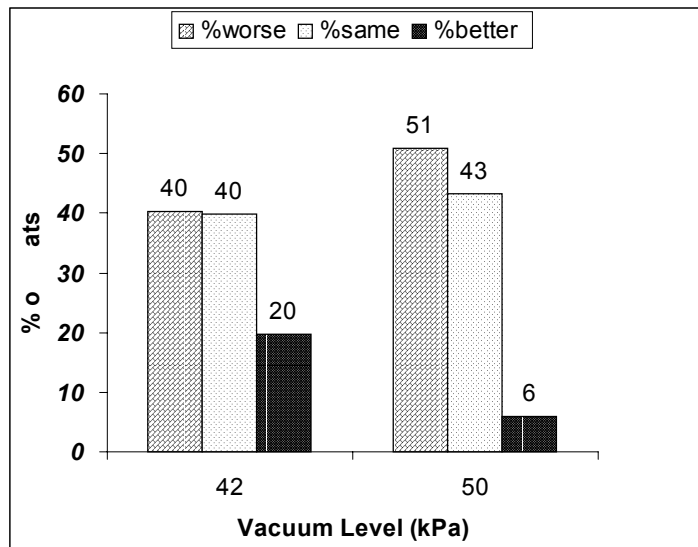
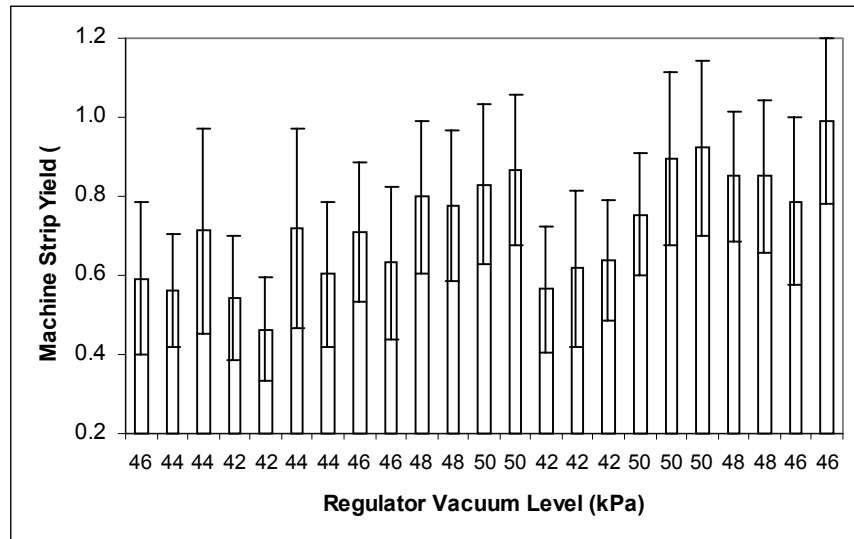


Figure 7. Percent of teats changing status during the 2-week intervals with regulator vacuum at 42 kPa and 50 kPa

The average machine strip yield measured at the beginning and end of each treatment interval is reported in Figure 8. As previously reported by Baxter et al. (1950) and Hamann et al. (1993), increased strip yield was associated with increased vacuum level:

$$Y_S = 0.037V_R - 0.98$$

$$(R^2 = 0.62)$$



**Figure 8. Average machine strip yield at the beginning and end of each treatment interval.**

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