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Joseph P. Harner

John F. Smith

W.F. Miller

*See next page for additional authors*

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## Abstract

Lactating dairy cattle were used to evaluate three different cooling systems. Eight cows were arranged in a replicated Latinsquare design and assigned to each of four treatments. Treatments were control, lowpressure soaking (LPS), high-pressure misting with 1.7 gallons per minute of water (HP-1.7), or high-pressure misting with 3.4 gallons per minute of water (HP-3.4). Cows were allowed to become heat stressed in a free-stall facility, and then were moved to a tie-stall barn for 2 hours of observations during four hot and humid afternoons. Respiration rates declined when heat abatement systems were used. Respiration rates at the end of the observation period were reduced by 20, 36, and 48% for HP-1.7, HP-3.4, and LPS, respectively. Rearudder skin surface temperature was reduced at a faster rate under the HP-4 treatment than with LPS, but the two treatments did not differ in final rear-udder skin surface temperature or vaginal temperature. The HP-3.4 treatment used the greatest amount of water during the 2-hour testing period. The result was a combination of air-cooling and soaking. Results indicated that a combination of air cooling and soaking may result in faster reduction of surface temperature. When only air cooling was used (HP-1.7), heat stress was reduced, but it was less effective than either LPS or HP-3.4. Use of a low-pressure soaking system is superior to high-pressure misting unless cattle become soaked by the high-pressure system.; Dairy Day, 2004, Kansas State University, Manhattan, KS, 2004;

## Keywords

Dairy Day, 2004; Kansas Agricultural Experiment Station contribution; no. 05-112-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 941; Dairy; Heat stress abatement; Cow comfort; Cow cooling



## Authors

Joseph P. Harner, John F. Smith, W.F. Miller, and B. Cvetkovic

# RESPONSES OF LACTATING HOLSTEIN COWS TO LOW-PRESSURE SOAKING OR HIGH-PRESSURE MISTING DURING HEAT STRESS

*M. J. Brouk, J. P. Harner[1], J. F. Smith, W. F. Miller, and B. Cvetkovic*

## Summary

Lactating dairy cattle were used to evaluate three different cooling systems. Eight cows were arranged in a replicated Latin-square design and assigned to each of four treatments. Treatments were control, low-pressure soaking (LPS), high-pressure misting with 1.7 gallons per minute of water (HP-1.7), or high-pressure misting with 3.4 gallons per minute of water (HP-3.4). Cows were allowed to become heat stressed in a free-stall facility, and then were moved to a tie-stall barn for 2 hours of observations during four hot and humid afternoons. Respiration rates declined when heat abatement systems were used. Respiration rates at the end of the observation period were reduced by 20, 36, and 48% for HP-1.7, HP-3.4, and LPS, respectively. Rear-udder skin surface temperature was reduced at a faster rate under the HP-4 treatment than with LPS, but the two treatments did not differ in final rear-udder skin surface temperature or vaginal temperature. The HP-3.4 treatment used the greatest amount of water during the 2-hour testing period. The result was a combination of air-cooling and soaking. Results indicated that a combination of air cooling and soaking may result in faster reduction of surface temperature. When only air cooling was used (HP-1.7), heat stress was reduced, but it was less effective than either LPS or HP-3.4. Use of a low-pressure soaking system is superior to high-pressure misting unless cattle become soaked by the high-pressure system.

(Key Words: Heat Stress Abatement, Cow Comfort, Cow Cooling.)

## Introduction

Summer heat stress reduces milk production and reproductive efficiency of dairy cows. Applying water to the skin of cattle or using evaporating water to cool the air around the cow are two common methods of reducing heat stress. These two methods are commonly refereed to as low-pressure soaking and high-pressure misting. Equipment costs (ownership and maintenance) are greater for high-pressure misting systems. Low-pressure soaking removes heat via conduction and evaporation, whereas high-pressure misting only removes heat by conduction. Low-pressure soaking may more effectively remove heat because water is a better conductor than air, and because a portion of the heat energy required to evaporate water from the skin is obtained from the cow.

The objective of this study was to determine the effects of low-pressure soaking and high-pressure misting on respiration rates, rear-udder skin surface temperatures, and vaginal temperatures of heat-stressed cows.

## Experimental Procedures

Eight lactating Holstein cows (4 first-lactation and 4 multiple-lactation cows) were arranged in a replicated 4 × 4 Latin-square

[1]Department of Biological and Agricultural Engineering.

design to evaluate three different heat-abatement systems. Multiple-lactation cows averaged 260 days in milk and were producing an average of 88.2 lb of milk. First-lactation cows averaged 251 days in milk and were producing 91.9 lb of milk. Cows were housed in open free stalls at the KSU Dairy Teaching and Research Unit and were milked twice daily. On four hot and humid afternoons, cattle were moved to a tie-stall barn at 2:00 p.m. during 2 hours of cooling treatments. Treatments were control (C), low-pressure soaking applied for 1 minute every 5 minutes (LPS), continuous high-pressure misting with 2 (1.7 gallons/hour) nozzles (HP-1.7), or continuous high-pressure misting with 4 (3.4 gallons/hour) nozzles (HP-3.4). All three heat-stress-abatement treatments also included axial flow fans that created 750 CFM of airflow over the cows. Respiration rates and rear-udder skin surface temperatures were measured and recorded at 5-minute intervals during the 2-hour period. Skin surface temperature was measured with an infrared thermometer. Vaginal temperature was measured and recorded every minute and subsequently averaged by 5-minute periods before data analysis. Data from the first and final 15 minutes were averaged as initial and final observations. All data were subjected to analysis of variance, with treatment as a fixed variable and period and cow as random variables. Time (5-minute interval) was used as a repeated measure within cow.

## Results and Discussion

Temperature of stalls (Figure 1) declined during the experimental period. Temperatures of the control stalls were greater ($P<0.05$) than when heat abatement systems were used. The HP-3.4 treatment reduced temperature the most and temperature reduction was correlated with the amount of water applied during the treatments. Relative humidity (Figure 2) increased with the addition of water from the HP-3.4 and LPS treatments.

Respiration rates (Table 1) were reduced ($P<0.01$) by each of the heat-stress-abatement systems. The LPS treatment was more effective than the high-pressure systems in reducing final respiration rates, and HP-1.7 was not as effective as HP-3.4. The HP-1.7 system only used about half as much water as the HP-3.4 system did. Cattle treated with HP-3.4 became soaked during the course of the testing period. As a result, the HP-3.4 treatment was actually a combination of soaking and evaporative cooling. Rate of respiration-rate decline differed among treatments (Figure 3). The control did not affect respiration rate. Rate of decline was greater for LPS than for either HP-1.7 or HP-3.4. Respiration rates of cattle cooled with HP-1.7 seemed to decline at first, but reached a stable respiration rate, compared with that of cattle cooled with HP-3.4 and LPS, which resulted in a continual decline during the testing period.

Rear-udder skin surface-temperature (Table 2) was reduced ($P<0.05$) by the heat-abatement systems. Cattle treated with HP-3.4 or LPS responded similarly, with cattle treated with HP-1.7 intermediate in response. Rate of rear-udder surface temperature decline (Figure 4) differed ($P<0.05$) among treatments. Using HP-3.4 resulted in the greatest rate of decline, followed by those of LPS and HP-1.7.

Final vaginal temperature (Table 3) was least for LPS and HP-3.4 and less ($P<0.05$) than HP-1.7 and control. The LPS and HP-3.4 treatments reduce vaginal temperature 2.7°F, compared with that of control. Rate of vaginal temperature decline (Figure 5) was greatest for HP-3.4 and LPS treatments, with HP-1.7 being intermediate. Lack of heat abatement (control) resulted in increased vaginal temperature during the experimental period.

Cattle cooled with HP-3.4 became soaked during the course of the experimental period. As a result, this treatment really represented a combination of the soaking and high-pressure misting. It is significant to note that the HP-3.4 system used the greatest amount of water, followed by that of LPS and HP-1.7. A response to the amount of water applied, as well as the method of application, was observed. Although LPS produced the lowest respiration rates, cattle from the LPS treatment did not differ from HP-3.4 in final vaginal temperature. Cooling cattle with either HP-3.4 or LPS was more effective than either the control or HP-1.7 treatment. These data indicate that there may be some advantage to the combination of reducing air temperature and soaking. Although the final vaginal temperatures of cattle treated with LPS and HP-3.4 did not differ, the rate of decline was greater for cattle treated with HP-3.4. When high-pressure misting does not soak the cow (HP-1.7), it is less effective than LPS in reducing heat stress of dairy cattle.

**Table 1. Initial and Final Respiration Rates of Cattle Cooled with Different Heat-abatement Systems**

| Treatment* | Initial | Final | SE |
|---|---|---|---|
| | Breaths/minute | | |
| Control | 110.8 | 117.5[a] | 4.2 |
| HP – 1.7 | 108.0 | 94.2[b] | 4.2 |
| HP – 3.4 | 109.2 | 75.0[c] | 4.2 |
| LPS | 111.2 | 61.8[d] | 4.2 |

*Control = no supplemental airflow or water treatment, HP-1.7 = 750 CFM airflow and 1.7 gallons/hour continuous high-pressure misting, HP-3.4 = 750 CFM airflow and 3.4 gallons/hour continuous high-pressure misting, and LPS = 750 CFM airflow and 4 gallons/hour of water via a low-pressure soaking system.

[a,b,c,d]Means within column having different superscripts letter differ ($P$<0.01).

**Table 2. Initial and Final Rear-udder Skin Surface Temperatures of Cattle Cooled with Different Heat-abatement Systems**

| Treatment* | Initial | Final | SE |
|---|---|---|---|
| | °F | | |
| Control | 98.1 | 98.1[a] | 1.0 |
| HP – 1.7 | 98.8 | 96.6[b] | 1.0 |
| HP – 3.4 | 99.0 | 94.6[c] | 1.0 |
| LPS | 98.8 | 95.7[c,b] | 1.0 |

*Control = no supplemental airflow or water treatment, HP-1.7 = 750 CFM airflow and 1.7 gallons/hour continuous high-pressure misting, HP-3.4 = 750 CFM airflow and 3.4 gallons/hour continuous high-pressure misting, and LPS = 750 CFM airflow and 4 gallons/hour of water via a low-pressure soaking system.

[a,b,c,d]Means within column having different superscripts letter differ ($P$<0.05).

**Table 3. Initial and Final Vaginal Temperatures of Cattle Cooled with Different Heat-abatement Systems**

| Treatment* | Initial | Final | SE |
|---|---|---|---|
| | °F | | |
| Control | 103.8 | 104.7[a] | 0.4 |
| HP – 1.7 | 102.9 | 103.3[b] | 0.4 |
| HP – 3.4 | 102.4 | 102.0[c] | 0.4 |
| LPS | 102.7 | 102.0[c] | 0.4 |

*Control = no supplemental airflow or water treatment, HP-1.7 = 750 CFM airflow and 1.7 gallons/hour continuous high-pressure misting, HP-3.4 = 750 CFM airflow and 3.4 gallons/hour continuous high-pressure misting, and LPS = 750 CFM airflow and 4 gallons/hour of water via a low-pressure soaking system.

[a,b,c,d]Means within column having different superscripts letter differ ($P$<0.05).

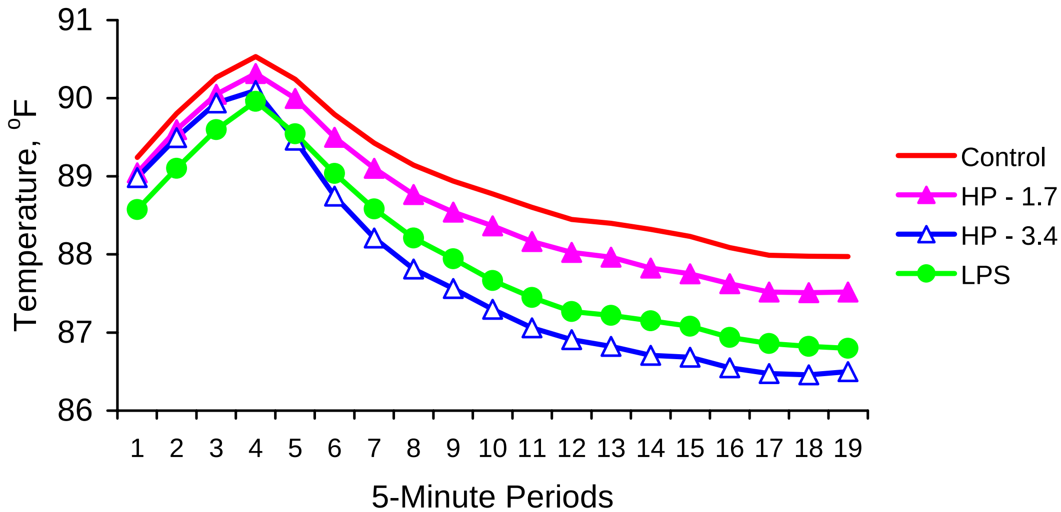


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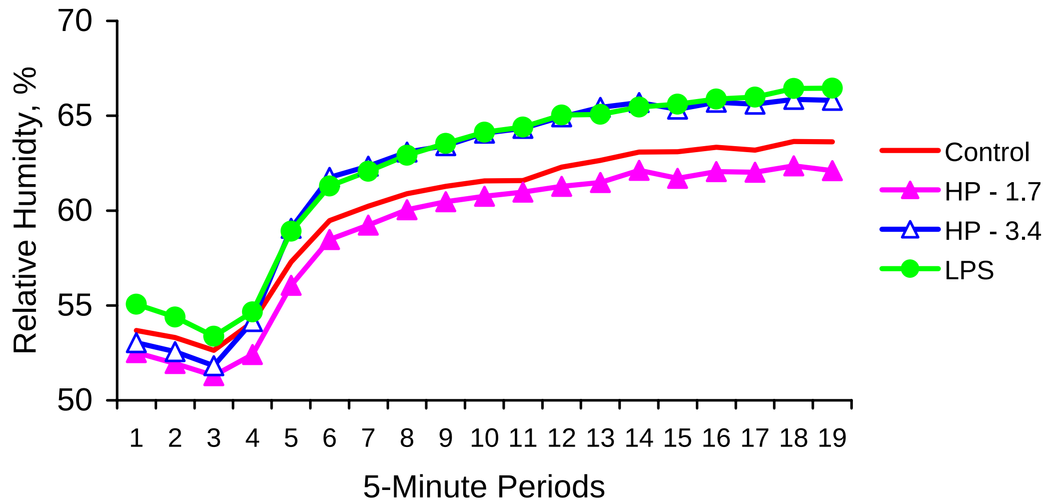
**Figure 1. Temperature of Stalls Equipped with Different Heat-abatement Systems.**




Control = no supplemental airflow or water treatment, HP-1.7 = 750 CFM airflow and 1.7 gallons/hour continuous high-pressure misting, HP-3.4 = 750 CFM airflow and 3.4 gallons/hour continuous high-pressure misting, and LPS = 750 CFM airflow and 4 gallons/hour of water via a low-pressure soaking system.

**Figure 2. Relative Humidity of Stalls Equipped with Different Heat-abatement Systems.**

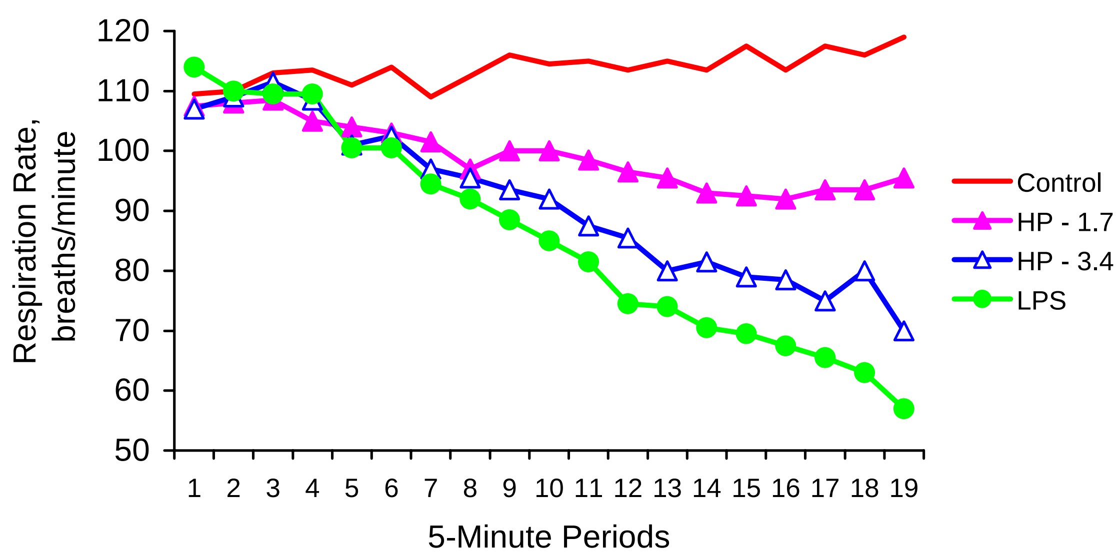



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**Figure 3. Respiration Rate of Cattle Cooled with Different Heat-abatement Systems.**

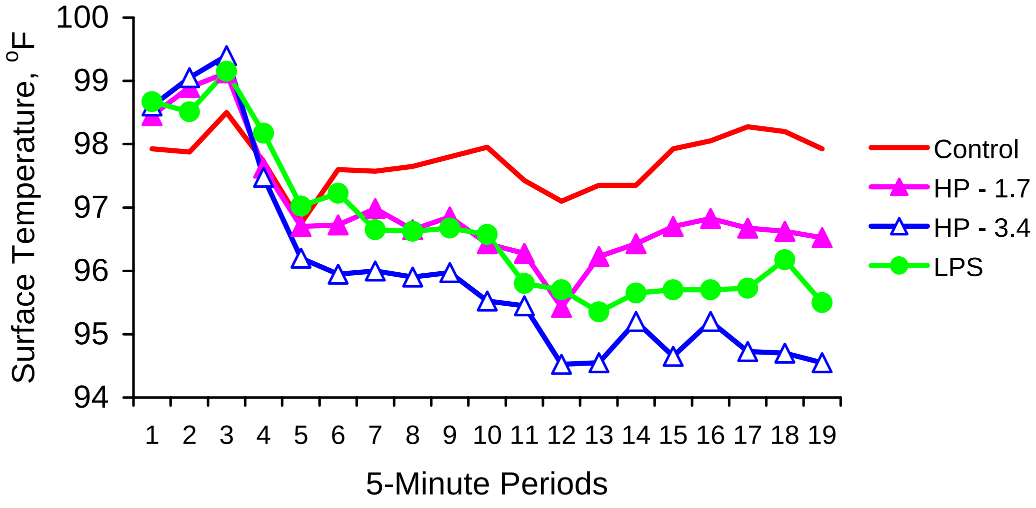


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**Figure 4. Rear-udder Skin Surface Temperature of Cattle Cooled with Different Heat-abatement Systems.**

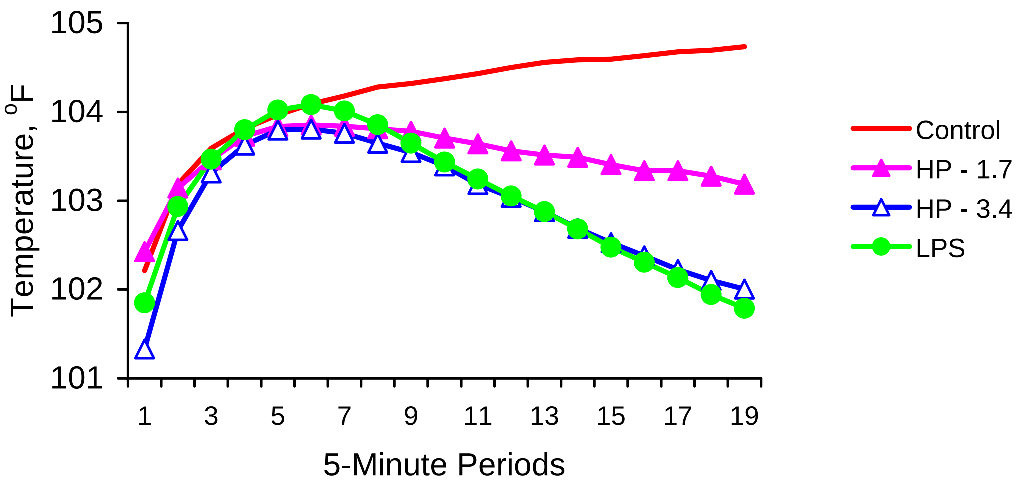


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**Figure 5. Vaginal Temperature of Cattle Cooled with Different Heat-abatement Systems.**