Practical Computerized Monitoring of Parlor Cow Flow

Steven C. Stewart, *DVM, College of Veterinary Medicine, University of Minnesota, St. Paul, MN*
Steven W. Eicker, *DVM, Valley Ag Software, Ithaca, NY*

Introduction

As dairies grow larger, efficient operation of the milking parlor becomes critical for many reasons. First, it is typically one of the largest capital investments on the dairy. Second, it is often the limiting resource to further expansion. Third, it requires a substantial percentage of the total labor force on the dairy. Fourth, it is often the place where disease detection occurs or cows are identified for other management needs. It is also often the actual site of treatment or sorting for further action. Therefore, constant monitoring of a parlor is necessary to keep it operating at peak efficiency.

Electronics in the form of automatic identification and electronic milk weighing meters, coupled with computers and herd management software, are increasingly being used to aid this monitoring. This area has much potential to allow better management control and decision making, but usually this potential (as well as the substantial investment for the electronics) is at best greatly under-utilized, if not wasted. This paper will discuss using electronically captured data to monitor and manage parlor performance.

Electronics and the Milking Parlor

Great strides have been made in electronics and computers in the last several years. Dairy farms and milking equipment manufacturers have been actively adapting and adopting this technology during this time. Currently, there are at least eight companies with these systems: Afikim, Alfa-Laval, BouMatic, Germania, Nu-Pulse, Surge, Universal, and Westfalia.

Features and capabilities vary from manufacturer, but some of the uses of electronics currently commercially available in parlor or parlor-related activities include:

1. Automated identification in the form of electronic transponders on each animal, coupled with some form of "reader" or antenna in the parlor.
2. Milk weighing devices (meters) capable of exchanging data electronically with a parlor controller computer, often in both directions.
3. Milk meters with milk flow sensors controlling automatic unit detachers.
4. Milk meters with other capabilities such as conductivity for disease detection.
5. Pedometry devices, used for estrus detection, either separate or as part of ID system.
6. Automated sorting via "cut" gates.

Typically, electronic systems have been sold primarily, if not exclusively, on the basis of measuring milk production to aid in managing production more carefully and detecting disease problems more quickly. While these uses may be beneficial, they are not the only ones; in fact, other uses may actually be more important and make the investment in these systems more justifiable.

Some of the possible uses of these systems include:

1. Monitoring the individual cows themselves.
   a. Milk production each milking.
   b. Change (deviation from "expected" milk) in milk production.
   c. Change in conductivity levels for mastitis detection.
   d. Unit on-time (duration) required for milking.
   e. Use of pedometry for estrus detection.
   f. Keeping information (fresh date, dry-offs, pen) current.
2. Automated sorting of animals for management tasks.
   a. Sick cows for examination and/or treatment.
   b. Reproductive examinations and estrus synchronization.
   c. rBST injections.
   d. Cattle movement-dry-offs, pen changes, and culling.
3. Monitoring of the parlor equipment to detect problems during:
   a. Milking.
   b. Wash-up.
4. Monitoring of cow flow and parlor personnel.
   a. Efficiency of unit attachment.
   b. Consistency of unit attachment routines.
   c. Efficiency of parlor filling and unloading.
   d. Efficiency of changes between groups of cows.

e. Overall cows per hour or milk per hour.

f. Failure to attach units or reattach kickoffs, etc.

This paper will not discuss in detail the uses for individual cow monitoring, for sorting of cattle, or monitoring of the milking equipment, as they are topics worthy of their own discussions. This paper will concentrate instead on the uses of the data for monitoring the efficiency of cow flow through the parlor.

Monitoring Cow Flow and Parlor Personnel

Most methods of monitoring parlor efficiency either have been very short-term (timing during a portion of a single milking), labor-intensive, lacking in detail, time consuming (reviewing videotapes), or not reflective of the actual parlor performance. Using data captured from milk metering devices can allow rapid, detailed, routine, and unintrusive monitoring of parlor efficiency at each and every milking with little additional effort.

Several factors, including number of milkers and desired milk quality, interact to determine parlor efficiency, but one of the most important is maximizing total pounds of milk per day being harvested in the parlor. Total cows milked per day (or per hour) is commonly used as a proxy for pounds of milk output, but too often it is used as the only measure.

In simplistic terms, increasing milk per hour can be achieved in one of three ways:

1. Increasing the production per cow.
2. Increasing the average milk flow while the units are attached.
3. Decreasing the amount of time that the units are not attached to cows.

Data Needed to Monitor Parlor Efficiency

The necessary data to capture for the analyses discussed include cow identification, time of identification, time of unit attachment, pounds of milk produced, duration of unit on-time, and the parlor stall the cow occupied. These data vary widely between different manufacturers. For instance, some provide both the attach time and entrance gate time to the nearest few seconds. Others only provide the time that the exit gate was opened, rounded to the nearest ten minutes. The latter prohibits most analyses: the order the units were attached, gaps between attachments, etc. All but one manufacturer provides stall milked-in, allowing electronic calibration of meters and detection of equipment problems.

Parlor Performance Reports

There is an endless number of types of reports that could be generated from these data. Some types of reports (examples will be in next section) that we have designed that commercial dairymen are finding useful include:

1. Summary reports following each milking (Figure #1).
   a. Total milk by pen and total herd.
   b. Milk and cows per hour by pen and total herd.
   c. Start, stop, and total times by pen and total herd.
   d. Average unit on-time.
   e. Milk per minute of unit on-time (average milk flowrate).
   f. Percent of time units actually on cows versus hanging.
2. Detail of sequence of unit attachments (Figure #2).
3. Detail of time intervals between unit attachments (Figure #3).
4. Detail of time for unit attachment for a given side and turn (Figure #2).
5. Detail of filling time for given side and turn.
6. Detail of time gaps between turns and between pens (Figure #2).
7. List of short unit on-times, likely kickoffs without reattachments.
8. List of cows with long unit on-times.
9. Graph of duration versus milk production (Figure #6).
10. List of "errors".
    a. ID system errors.
    b. Cows not identified as entering parlor.
    c. Cows entering parlor, but no unit attached (Figure #5).
    d. Cows coded as dry but identified as having entered parlor.
    e. Cows milked in a "wrong" pen.
    f. Cows manually detached.

Example Reports

Below is an example of a summary report that is printed following the completion of each milking. As should be evident, information is reported on total milk, milk per hour, cows per hour, total cows, cows per hour, total time in parlor, start time, stop time, average milk per minute of unit on-time, average unit on-time, deviation from expected milk, and number "missed". This information is reported for each pen and for the total herd.

These reports have proven to be of great value to dairymen when used on a regular basis to quickly either detect changes or problems in groups of cows or during a milk shift.

PEN	Total Milk	Milk /Hr	Milk /Cow	Cows	Cows /Hr	Total Time	Start Time	Stop Time	Avg #/m	Avg Dur	Avg Dev	Not ID
1	7845	4128	33	235	123	1:54	4:54	6:48	5.1	6.6	-1	4
3	6910	3574	37	183	94	1:56	6:52	8:48	5.6	6.9	-2	2
4	7791	3412	41	189	82	2:17	8:55	11:12	5.8	7.3	-3	1
5	4528	2469	23	189	103	1:50	11:15	13:05	4.4	5.4	-1	1
2	2650	3533	40	65	86	0:45	13:11	13:56	5.4	7.9	-2	1
6	2587	2463	36	71	67	1:03	13:54	14:57	3.5	10.6	-2	1
7	2362	2624	35	67	74	0:54	13:54	15:48	4.9	7.7	-3	3
8	302	1208	50	6	24	0:15	16:03	16:18	4.8	10.8	-7	0
9	73	312	18	4	17	0:14	16:05	16:19	2.9	8.3	-1	8
==	=====	====	====	====	====	=====	=====	=====	===	===	===	==
	35048	3069	34	1009	88	11:25	4:54	16:19	5.1	7.0	-2	21

Units were attached 32 percent of the time

Figure 1. Summary parlor performance summary report example.

In the above example note the line that states the percent of time units were attached. This is the total time units were on cows milking versus the total time spent in the parlor. In many herds this number is in the teens or 20s. In higher efficiency parlors it typically has been in the upper 30s. While higher is usually better, it should be noted that very high percentages may mean that units are being left on all cows a prolonged time, being detached too soon, or cows are being moved excessively fast entering or exiting parlor.

To minimize the time milking units are idle (unattached to cows), the time between unit removal from one cow to attachment of the same unit to the next cow must be as short as possible. Delays can occur for a variety of reasons, including:

1. Delays in cow entrance into the parlor from holding area.
2. Delays from entering parlor and occupying a parlor stall
3. Delays between the time a cow occupies a parlor stall and unit attachment.
4. Delays when exiting the parlor.
5. Delays due to an empty holding area, e.g., between two groups of cows.
6. Delays from attachment of first unit on a side to the last unit on same side.
7. Delays due to long duration of on-time for one cow, holding up rest of side.
8. Delays due to equipment factors such as peak milk flow and detacher settings.
9. Delays due to lower peak flow due to inadequate pre-milking stimulation.

Electronic data collection provides the opportunity to identify the presence of a delay and in some cases help pinpoint the cause. In the below example of a double 10 parlor (header line of 1 to 10 refers to parlor stall number by side), the table is displayed in the order of unit attachment. Note:

1. Time to attach units on a side was 3 to 4 minutes.
2. Turn 2 Side 1 took 18 minutes from the time unit was attached to the final unit being removed. Since unit attachment time was relatively short, would indicate one or more cows had a prolonged duration. This could be documented by selecting duration to be displayed rather than order.
3. Turn 4 Side 1 & 2 had gaps from the previous sides of 13 and 17 minutes. Note that this is likely due to the fact that there was a change in groups, with the holding pen being empty for a period of time.
4. Turn 1 Side 2 was attached in reverse order.
5. Turn 3 Side 1 was attached in somewhat random order.

								Milking 1							Order						
T	S	Pen	MY	Gap	Att	Det	FstAt		1	2	3	4	5	6	7	8	9	10
==	=	===	==	===	===	===	=====		===	===	===	===	===	===	===	===	===	===
1	1	1	33	0	4	15	04:58		1	2	3	4	5	6	7	8	9	10
1	2	1	30	0	4	15	04:54		10	9	8	7	6	5	4	3	2	1
2	1	1	30	6	3	18	05:19		1	2	3	4	5	6	7	8	9	10
2	2	1	33	5	3	12	05:13		1	2	3	4	5	6	7	8	9	10
3	1	1	34	3	4	12	05:41		1	2	7	5	6	3	4	8	9	10
3	2	1	35	7	4	12	05:31		1	2	3	4	5	6	7	8	9	10
4	1	2	34	13	3	13	06:06		1	2	3	4	5	6	7	8	9	10
4	2	2	35	17	4	14	06:00		1	2	3	4	5	6	7	8	9	10
==	=	===	==	===	===	===	=====		===	===	===	===	===	===	===	===	===	===
20	2		32	6	3	11												

T=Turn, S=Side, MY=Milk Yield.

Gap Time first unit attachment minus time last detach same side previous turn.
Att Time last attach minus first attach, same side same turn.
Det Time final detach minus first attach, same side same turn.
FstAt Time of day first unit attachment.

Figure 2. Parlor performance detail report example.

Another example of a useful display is timing (in seconds from first unit on) of attachment of the units. In the example below the milker was supposed to prepare and attach in groups of five cows. On the first turn first side the order and timing are correct, on side two the order is correct, but units were attached without a break between stall 5 and 6, likely meaning the desired prep procedure was not followed.

								Milking 1						Time of Attachment					
T	S	Pen	MY	Gap	Att	Det	FstAt		1	2	3	4	5	6	7	8	9	10
==	=	===	==	===	===	===	=====		===	===	===	===	===	===	===	===	===	===
1	1	1	33	0	4	15	04:58		0	15	31	44	60	100	115	132	145	163
1	2	1	30	0	4	15	04:54		0	6	12	17	23	32	41	48	52	61

Figure 3. Parlor performance detail report example.

Other possible data that are available to be displayed include the duration of unit on-time, ID of cow, milk production, conductivity, delay from time of ID to attachment, pen assigned to cow, average flow rate of milk, deviation from expected milk, and how long each prolonged duration cow held up her side. Future data that may be displayed include peak flow rate, pedometry data, deviation of conductivity, etc.

Information on individual cows can be displayed by "clicking" on a point in the table. The ID, milk production, duration of unit on-time, deviation from expected milk, time of day of unit attachment, and pen of cow is displayed. A sample is shown below:

```
+--------------------------------------------------+
| Cow: 8436  Milk: 20  Dur:  5.3  Dev:  4  Time: 06:43  Pen: 8 |
|            Please press [Enter] to continue      |
+--------------------------------------------------+
```

Figure 4. Individual cow information from parlor performance detail report.

Lists of Cows with Very Long or Very Short Durations

Individual cows with prolonged duration of on-time will increase the time between refills in most parlor designs, depending where she was attached early or late on that side. While it has been popularly recommended, putting these cows in their own group may not be the optimal solution. These cows will become less of a problem as manufacturers allow setting a maximum attach time such as 7 or 10 minutes. The possible loss incurred by culling a very few cows that require longer than the maximum milking time is likely far outweighed by getting the rest of the herd back to eating and lying down, rather than prolonged standing on concrete.

Interestingly, cows with very short durations also represent areas for improvement. There has recently been much press about elevated cows-per-hour-per-milker. Too often this has been translated into speed rather than quality. For instance, not reattaching units kicked off early is almost certainly not desired, unless higher cows-per-hour is the only goal. Monitoring instances of many cows with ultrashort milking times can increase the profits of the dairy.

Other Examples

We have documented and confirmed examples of cows that entered the parlor, were properly identified, but were released by accident by a milker pressing the exit button prior to milking the cows. During the day shift, these cows are usually caught and run through the parlor again; at night, they likely return to their pen unmilked. These "errors" are printed out after each

milking as part of the summary report. An example is below:

```
1584 No milk from    Stall:  3; ITOD= 2:20 ATOD= None PEN=  7 Dur= 0.0
2333 No milk from    Stall:  4; ITOD= 2:21 ATOD= None PEN=  7 Dur= 0.0
3330 No milk from    Stall:  7; ITOD= 2:22 ATOD= None PEN=  7 Dur= 0.0
3381 No milk from    Stall:  6; ITOD= 2:22 ATOD= None PEN=  7 Dur= 0.0
3392 No milk from    Stall:  5; ITOD= 2:22 ATOD= None PEN=  7 Dur= 0.0
3534 No milk from    Stall:  1; ITOD= 2:18 ATOD= None PEN=  7 Dur= 0.0
3628 No milk from    Stall:  8; ITOD= 2:23 ATOD= None PEN=  7 Dur= 0.0
5330 No milk from    Stall:  9; ITOD= 2:23 ATOD= None PEN=  7 Dur= 0.0
5518 No milk from    Stall:  2; ITOD= 2:19 ATOD= None PEN=  7 Dur= 0.0
6628 No milk from    Stall: 10; ITOD= 2:23 ATOD= None PEN=  7 Dur= 0.0
```

Figure 5. Example "error" messages from parlor performance summary report.

Note that the cows all had times of ID (ITOD) and parlor stall assigned, but no time of attachment (ATOD) and no milk or unit on-times. Note also that the ITODs are all near each other and that the stalls are all on the same side. The errors are printed in ID order, but the stall sequence can be discerned with minimal effort. As mentioned earlier, other error messages might concern ID system errors, cows not identified as entering parlor, cows coded as dry but identified as having entered parlor, cows milked in a "wrong" pen, or cows manually detached. These messages are critical to keeping the system functioning and serve as constant reminders to perform timely and accurate data entry.
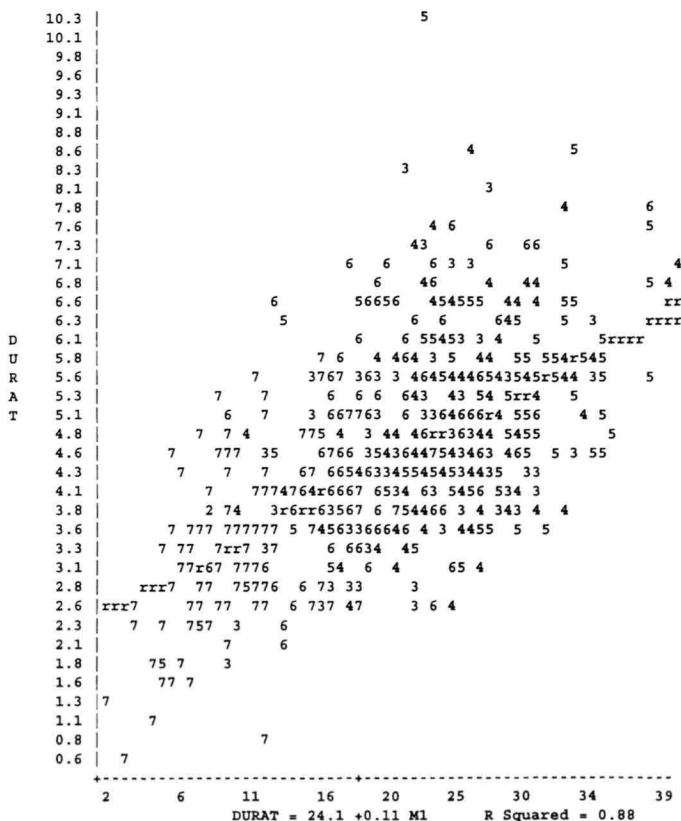
```
     10.3 |                              5
     10.1 |
      9.8 |
      9.6 |
      9.3 |
      9.1 |
      8.8 |
      8.6 |                        4        5
      8.3 |                   3
      8.1 |                        3
      7.8 |                           4        6
      7.6 |                  4 6               5
      7.3 |                43    6  66
      7.1 |          6  6    6 3 3      5          4
      6.8 |             6    46    4  44         5 4
      6.6 |        6    56656  454555  44 4  55       rr
      6.3 |        5         6  6   645   5  3     rrrr
  D   6.1 |          6  6 55453 3 4   5      5rrrr
  U   5.8 |                7 6   4 464 3 5  44  55 554r545
  R   5.6 |        7    3767 363 3 46454446543545r544 35    5
  A   5.3 |      7  7      6  6 643  43 54 5rr4   5
  T   5.1 |      6  7    3 667763  6 3364666r4 556    4 5
      4.8 |     7  7 4    775 4  3 44 46rr36344 5455        5
      4.6 |    7   777  35    6766 35436447543463 465  5 3 55
      4.3 |    7   7  7   67 6654633455454534435  33
      4.1 |      7    7774764r6667 6534 63 5456 534 3
      3.8 |         2 74   3r6rr63567 6 754466 3 4 343 4  4
      3.6 |    7 777 777777 5 74563366646 4 3 4455  5  5
      3.3 |    7 77 7rr7 37    6 6634 45
      3.1 |     77r67 7776     54 6  4      65 4
      2.8 |   rrr7  77 75776  6 73 33     3
      2.6 |rrr7    77 77  77  6 737 47     3 6 4
      2.3 |  7  7  757 3    6
      2.1 |           7  6
      1.8 |   75 7   3
      1.6 |    77 7
      1.3 |7
      1.1 |    7
      0.8 |           7
      0.6 |  7
          -------------------+-------------------------
          2    6    11    16    20    25    30    34    39
             DURAT = 24.1 +0.11 M1       R Squared = 0.88
```

Figure 6. Graph of duration of unit on-time versus production.

Another use of the data is shown above. This is a graph of unit on-times versus milk production. It should be obvious that higher producing cows take a longer period of time to milk. The regression line as well as the R squared value can also be displayed. In addition, one can see that relatively few cows in this example have unit on-times exceeding eight minutes, suggesting a maximum cutoff time of about 8 minutes if it was possible to set a maximum duration for all animals.

Overview of Design of Daily Milk Systems

So far, only the positives of using daily milk systems have been discussed. Unfortunately, there are negatives that one must be aware of before making the quite substantial investment for one of these systems. In fact, there have been many disappointed and discouraged dairymen when these systems did not deliver as promised. These negatives arise from the complexity of maintaining electronic devices in a harsh, wet, electrical noise-filled environment, from unwise shortcuts in design by dealers and herd owners in the name of cost-savings, and from a misunderstanding of what is needed to maintain these systems in good working order. These hurdles should be clearer with some background on the design of daily milk systems.

Automatic Cow Identification

Each cow is fitted with a transponder that is either worn around the neck or strapped to her leg. These transponders are read as cows enter the parlor. The transponders last a very long time, but they do fail. Most manufacturers expect their tags to last five to seven years. On average, this means one fails approximately every 2000 cow days. This means a 4000 cow dairy has a couple fail per day, and a 500 cow dairy loses one or two a week. Therefore, one of the routine tasks that must be performed on these dairies is to detect faulty tags and replace promptly. In addition, all cows need to be given a transponder at the time of first freshening.

Two different strategies are used for reading the cows in the parlor. Some systems have a single antenna (or "curtain") at the entrance to each side of the parlor. As the cows enter one at a time, their transponders are recorded in order, and the resulting milk weights are then lined up with the cows. The other method involves placing an antenna at each stall, so that a cow is identified where she is milked. As parlors get larger, the savings on antennas becomes substantial. In larger parlors individual stall antennae can easily add 50% to 100% to the cost of the system.

Neither system has perfect identification. When there are multiple antennas, the range on each one needs to be adjusted so that only the cow in the current stall is read, regardless of her peculiar position.

When there is only one antenna per side, a short mathematical discussion may be informative. Assume a 1000 cow dairy, with a double 20 for ease of calculation. Most manufacturers will claim up to 99% identification (that is, if 100 cows walked through the antennae, 99 transponders would be read). That leaves 1% or only 10 cows that are missed. However, in a single antenna system, each cow not identified in a turn will eliminate the other 19 cows unless corrected, because one does not know which stall the cow is in. There could be zero to 19 incorrectly assigned milk weights on that turn.

Thus, the difference between at the stall vs entry gate identification is 10 vs about 200 cows with missing or possibly wrong information. Smaller dairies with an entry identification system can achieve perfect identification, so long as milkers correct every computer mistake, but this is not the purpose of automatic ID!

Manufacturers have been reluctant to admit this difference, as the other manufacturers will use the information as a marketing ploy, even though the competing system may not be better. Worse, most systems have an option that assigns the cow's weekly average milk weight or the group average to animals that were not identified. This option should be disabled, as it hides the problem. **Bad or wrong information is worse than missing information in nearly all cases.** In fact, many dealers are unaware that this option is enabled on their dairies and are quite happy to see that all cows received milk weights!

One company has introduced a form of "artificial intelligence" to help identify and correct identification problems arising with missing or bad transponders. This has been a much needed improvement, but more work is needed in the area of inexpensive, yet accurate ID, with the "accuracy" stated as percent of cows properly receiving their true milk weights, not just the percent of transponders an antennae will properly read.

In many cases there has been problems with the physical layout of the entrance gate systems. Too often shortcuts have been taken that allow cows to back in and out of the entrance, get too near the antennae in the exit alley, or cause deficiencies in the wiring or shielding of electrical motors that produce electrical noise.

Parlor Controller Software versus Herd Management Software

Typically, there are actually two computer systems. The parlor system runs the meters and ID system—a full-time job for most any computer. These parlor controllers often appear just like a black box from the outside, but they are typically a full-fledged computer inside a rugged, tamper-proof case.

Often the parlor controller software is also marketed as a herd management software package, but in most cases the herd manager actually needs a more

extensive management software package. The herd management software is usually in a separate computer, containing much more extensive information: breedings, diseases, treatments, DHIA components, pedigree information, previous lactation data, etc.

These two systems must communicate with each other on a routine basis. The management computer must "import" milk weights, and other measurements, such as stall number, time of ID, start time, duration, pen, steps walked, conductivity, fall-off flags, alarm flags, etc. It must "export" back to the parlor system various data such as pen, fresh date, dry date, status, cut gate or withhold flags, and perhaps a low-milk cutoff weight. Communication is not a one-way street—information needs to flow both direction. A program that downloads milk weights once a month cannot claim to have an "interface".

These parlor controller systems vary greatly in their capacity. Some hold only the most recent weight, whereas others hold every milk weight from the past week. Some allow weight transfer at any time—others must only be interrogated between milkings. Some require cut flags to be set or reset before every milking, whereas others allow scheduling cows to be cut well into the future.

Costs

Will this technology cash flow? Will it be superior to competing uses of funds? Perhaps the greatest determination of the payoff is the current bottleneck on the dairy. If heat detection is near perfect, if the parlor has excellent motivated milkers, if diseases are both few and easily detected, and if management is all in order, the return from electronics may not be justified. Dairies with accurate electronic cow identification can accrue great benefits from these systems; dairies with poor identification tend to tear out these systems after a year or so because wrong information is far worse than none at all.

Conclusions

The purpose of this paper is to discuss some of the opportunities that may be available from currently available parlor electronics: automatic cow identification and milk metering. Typically, these systems have been marketed as tools for improving cow management—improved heat detection, earlier disease detection, more accurate production monitoring, etc. There are additional benefits that may even be more important than monitoring the cows: monitoring the people who work with the cows and monitoring the parlor in which they are milked. It is almost certain that additional capabilities will be added to the parlor systems of the future. The benefits will be either to better monitor the cow, the people, or the equipment.

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