Using farm-based software for monitoring of milking system performance and validation of data acceptability in herd recording programs

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Abstract

Herd recording programs have traditionally relied on the use of third-party owned weighing devices for collection of milk weights and samples. As dairies continue to invest in technology, including milking systems with on-farm meters and samplers, herd recording organizations have moved towards using farmer-owned devices for data collection. While periodic meter water test calibration is one option for verifying meter accuracy, it may be both cost- and time-prohibitive and does not provide on-going monitoring of the milking system. The use of computerized software solutions can provide the recording organization with an assurance of accuracy of data collected, and provide the dairy with tools for monitoring system performance on a routine (i.e. daily, weekly, etc.) basis. There are limitations to the farm-based software programs; however the benefits to both the dairy and the herd recording organization outweigh these limitations. These benefits include a higher level of confidence in data validity, increased value of recording programs and services to the dairy, and the integration of farmer-owned equipment and software into a modern data collection system.

Keywords: dairy herd improvement, milk recording, recording devices, computerized solutions

Background and perspective

The use of approved recording devices to obtain milk yield estimates and representative milk samples is an essential component of any milk recording program. Traditionally, the devices used in recording programs are owned, maintained, and supplied to dairy owners by the recording organization with the recording event(s) conducted on a periodic basis (most often monthly). Periodic recording events are either conducted in a supervised or unsupervised manner and involve animal identification, milk yield recording and obtaining representative milk samples for each cow in the herd. These recording devices are commonly referred to as portable or monthly meters and are calibrated (and subsequently certified) on an annual basis by trained and qualified persons.

Using these periodic estimates of yield and component analysis, individual cow and herd performance for the recording period is calculated. The resulting herd data is used by both the dairy owner for management of the herd; respective breed association(s) or herd books for pedigree information; and by the recording organization for genetic and management research.

The demands of today's dairy for immediate data access for all individuals in the herd, coupled with the technological advancements in identification and recording technology, have resulted in modern dairies investing in on-farm milk recording and management systems.

These in-place recording devices or daily meters have the ability to provide data to milk recording organizations efficiently, but also present challenges. The challenge for recording organizations is to integrate data collection using daily meters while maintaining an assurance of the validity of all data entering the program.

Changes in herd dynamics

As in many counties, the United States dairy herd continues to be redistributed in fewer herds with of a larger size. Figure 1 illustrates the decline in the number of herds participating in herd recording programs in the United States. This decline is proportionate to the decline in the total number of dairy herds in the United States over the same time period. However, as herd numbers decline, there is an increase in the number of cows participating in milk recording programs (Figure 2). This increased participation comes from herds of all sizes and reflects the need for quality management data for the herd. As illustrated in Figure 3, the distribution of the 4.37 million cows on milk recording programs includes nearly 2 million cows housed in herds of 750 cows or larger. While these trends in the herd numbers and average herd size are not unique to the United States, the distribution of cows in milk recording programs across herd size tends to be more extreme and presents unique challenges in validation of data accuracy from herds of all sizes. To ensure that quality data is used for both genetic and management programs, a uniform program that is size-neutral yet practical is imperative.

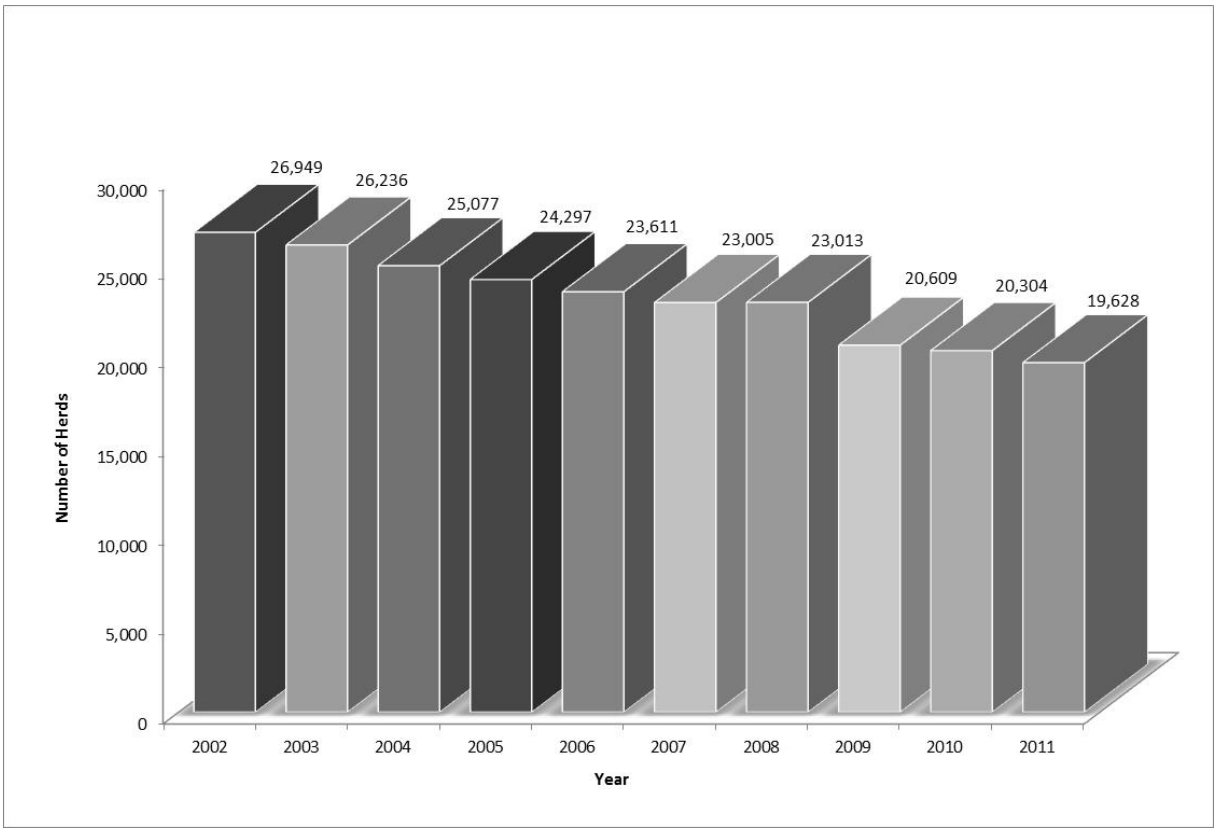

Figure 1. Herds in milk recording programs in US from 2002 to 2011.

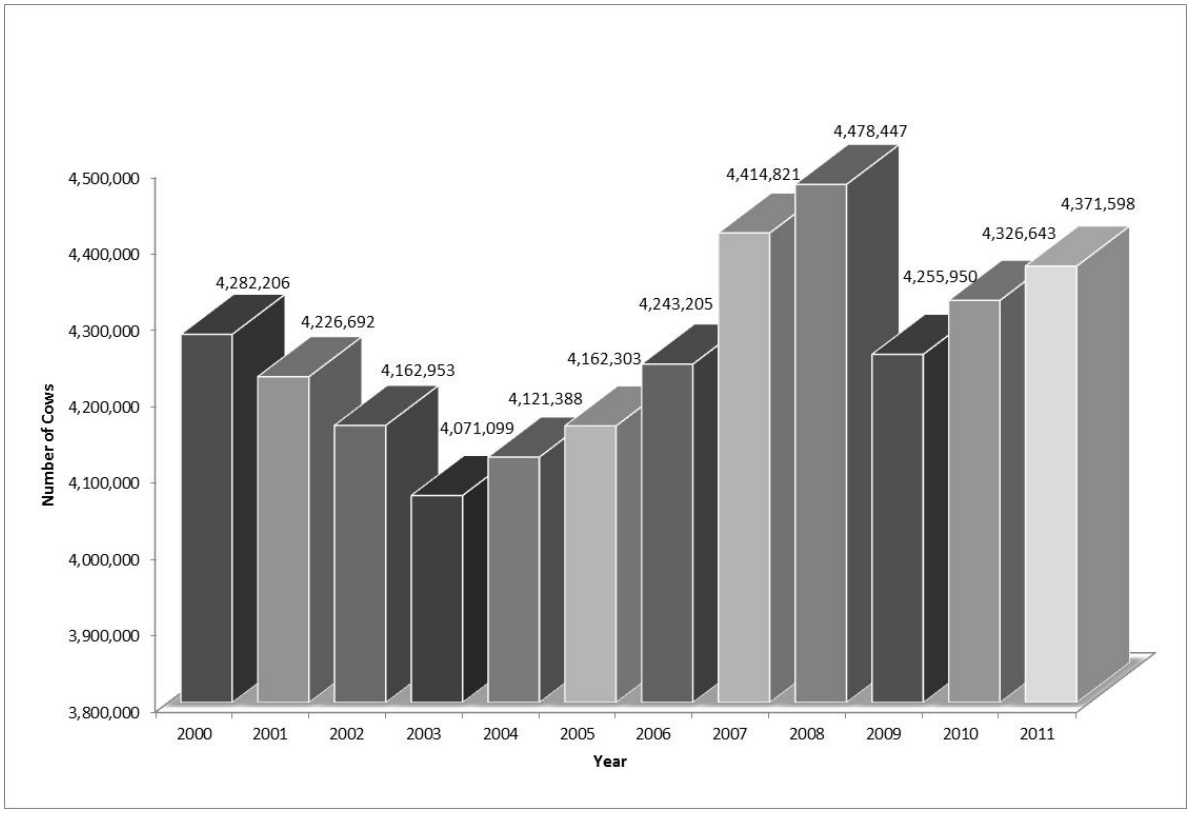

Figure 2. Participation of cows in milk recording programs in the US from 2000 to 2011.

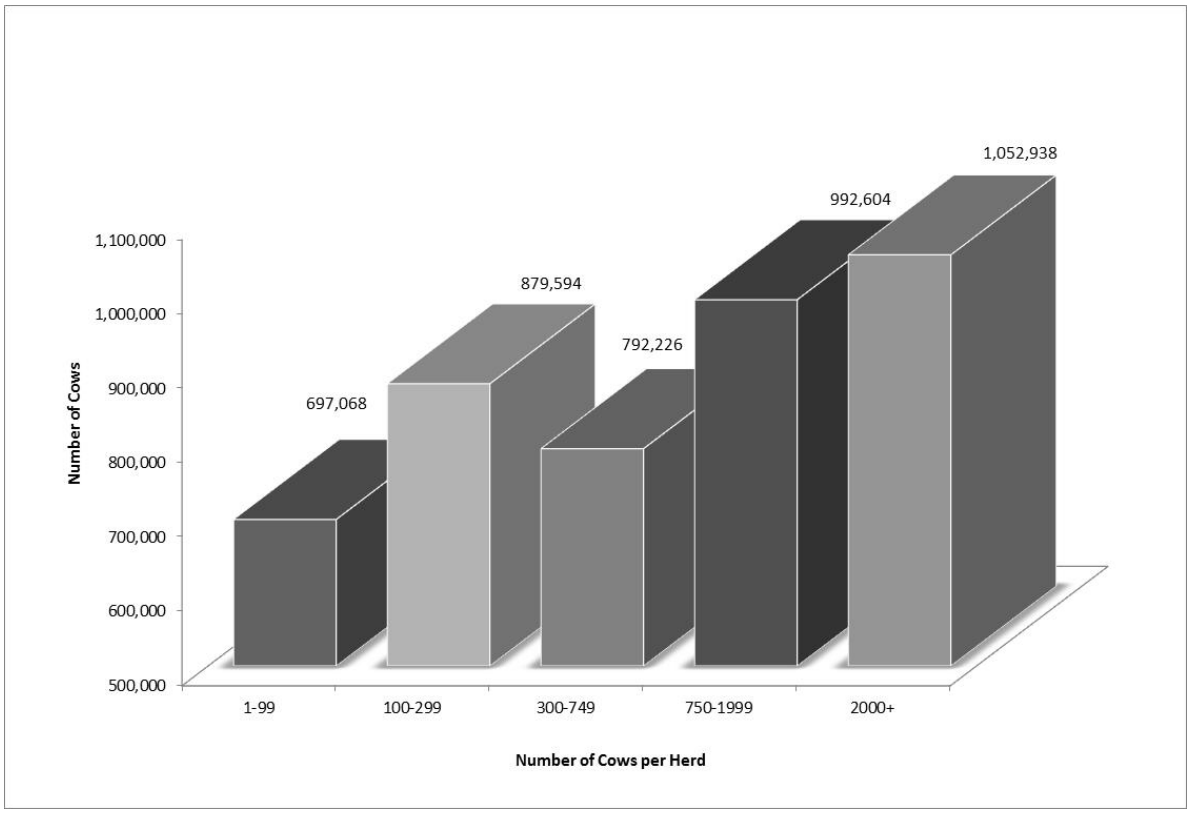

Figure 3. Distribution of cows by herd size on milk recording programs in US in 2011.

Collection of milk yield data from these herds of varying sizes relies on the use of ICAR-approved recording devices, however the type and ownership of these devices varies across herd size. While the majority of milk yields are collected using monthly meters owned by the recording organizations, the number of daily meters owned by respective dairies participating in milk recording programs has and continues to grow. As noted in the Table 1, the number of daily meters used is increasing in US herd recording programs - a result of both increasing investment by these larger dairy operations and by milk recording organizations integrating these devices into periodic herd testing programs.

While not exclusive to the herds of larger size, these meters present unique opportunities for efficient data transfer for recording organizations. These daily meters also present challenges with respect to data accuracy over repeated recording events as control of calibration and maintenance of these meters is no longer under the auspices of the recording organization. Traditionally the estimate of milk yield is based on a recording event that may represent only one or two milking during the recording period. With daily meters, milk yield from multiple consecutive milkings may be used. These multiple events may represent as many as 30 consecutive milkings during the recording period and contribute additional information to the database.

The standard for calibration of both monthly and daily meters is a periodic water test; however herds with daily meters may need more periodic monitoring of these meters (and the milking system). The use of statistical performance reports or computerized milking system solutions is an attractive alternative to the water test calibration from both a time and cost perspective for many dairies using daily meters. This report is also a viable validation procedure for data accuracy by milk recording organizations, a trend also observed in Table 1.

Table 1. Distribution of milk recording devices[1] in the US from 2008-2011.

	Monthly Meters				Daily Meters			
	2008	2009	2010	2011	2008	2009	2010	2011
Total Meters	112,389	110,117	107,369	92,289	46,875	49,318	56,034	89,167
Calibration method used								
Water Test, n	112,389	110,117	107,369	92,289	32,016	27,470	27,289	36,648
Water Test, %	100	100	100	100	68	56	49	41
Statistical, n					14,859	21,848	28,745	52,519
Statistical, %					32	44	51	59

[1] Number of recording devices represents devices reported to and certified by National DHIA/Quality Certification Services from herds participating in recording programs; not the number of devices installed on dairies

On-farm recording systems involve more than a calibrated milk meter

When using monthly meters owned by the milk recording organization, there is high expectation of data accuracy and validity. This expectation exists as the recording

organization has protocols for the periodic calibration and maintenance of these meters. At a minimum, these monthly meters are calibrated on an annual basis at a 2% tolerance level. Data recording is manual process that involves cow identification and recording of the proportional estimate of milk yield. Further, the use of these monthly meters occurs across multiple herds, distributing any potential bias randomly across cows recorded.

When using daily meters that are specific to a dairy, there are additional considerations before data may be accepted by the recording organization. While each daily meter is calibrated at the time of installation, the actual use of these meters is part of a milking system involving multiple components, each a source of potential errors and/or bias. As previously noted with respect to monthly meters, data recording is a labor-intensive process. In contrast, data recording and data flow tends to be more automatic in nature with labor inputs focused on technology maintenance rather than manual inputs. It is logical that a computerized report or solution may be used to evaluate the milking system on a periodic basis.

Figure 3 illustrates the various components that should be considered as part of a milk recording system when using daily meters. In this simplistic schematic, the ICAR approved meter and sampling device is still a key component, but evaluation of the acceptability of data should be based on a 'milking stall' basis as opposed to a 'milk meter' basis. The yield recorded by the milk meters is simply a numeric value if the yield cannot be associated with a valid animal ID. Further, the animal ID, milk yield, milking stall, and milking time must be captured at each milking event and communicated to the on-farm computer for later data transmission to the milk recording organization. It is also possible that the errors or bias in the system from components other than the milk meter is greater than the bias of the milk meter itself.

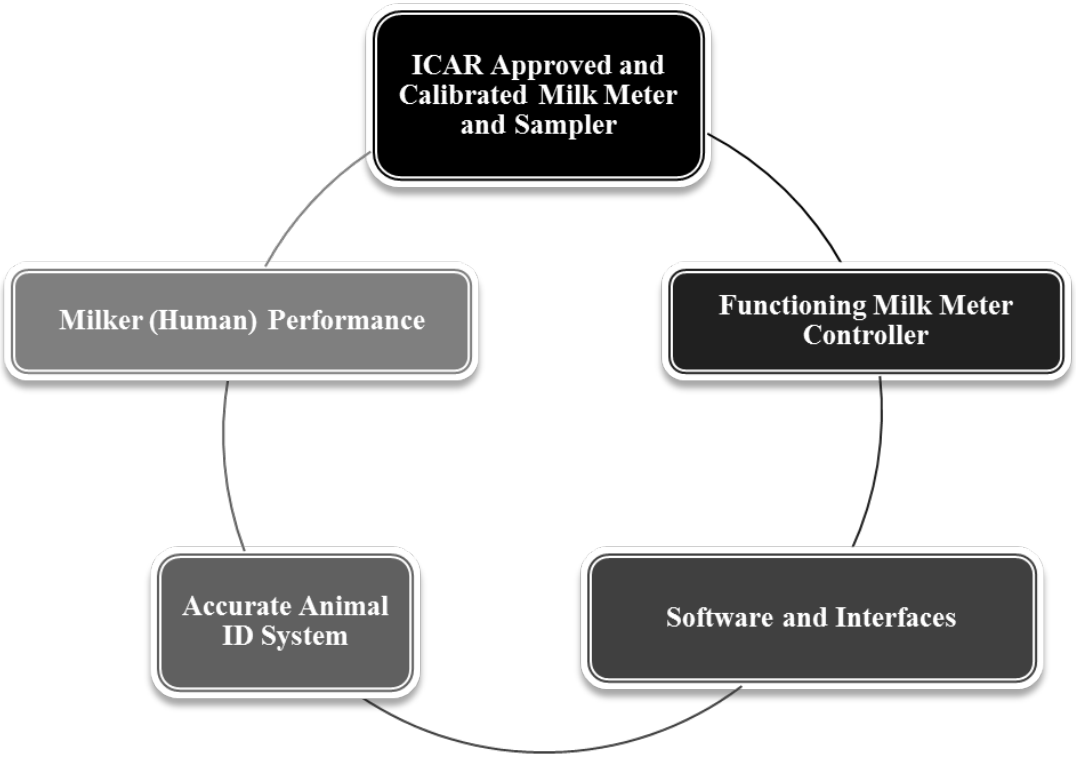

Figure 4. Components required for a computerized solution report daily meters.

Components of computerized solution or statistical milking stall report

To effectively evaluate a dairy using daily meters for milk recording, there are several key data points needed for a computerized solution or performance report to accurately estimate a deviation for each milking stall. This report is based on the concept of evaluating expected milk yields for each cow based on previously measured actual yields. By computing deviations for each cow and subsequently evaluating these yield deviations on a milking stall basis, an estimated deviation for each stall is calculated for the time period evaluated.

Decision rules for data exclusion or inclusion are necessary with a calculated solution report. With respect to the calculation of the expected milk yield, it is desired to have at least nine previous milking events represented in the calculation. The expected milk yield is adjusted for a 'herd factor' at the most recent milking event. More precision is gained by comparing like milkings, accounting for potential variation in milking times over a 24-hour period. As for measured milk yields that equal zero (missing milk yields), it is recommended to exclude these observations from the calculation of both expected yield and determining the herd factor adjustment to prevent undue bias.

The theoretical model recommends the exclusion of cows that are less than 30 days in milk. To evaluate potential outliers using the current model, data from herds milking twice (Table 2) and three (Table 3) times daily were evaluated. Using expected milk yields adjusted for the herd yield factor, the total number of potential outliers was less than 1% of the observations. The number of outlier trended higher for the herd milked twice daily, an expected outcome due to a potentially larger variation in the milking times of individual cows within the herds. It was also observed that the majority of the outliers were in cows that were less than 28 days in milk (DIM), validating the decision rule to exclude all cows less than 30 DIM for the computerized solution report. Additional outliers based on yield were also identified, but exclusion should be conservative as to avoid excluding all data observations for a specific milking stall.

Table 2. Distribution of potential outliers in herd milked two times daily[1].

	Expected Milk Yield, Adjusted for Herd Effect							
	<65%	<70%	<75%	<80%	>120%	>125%	>130%	>135%
Observed, n	12	22	33	69	77	33	15	12
Observed, %	0.07	0.12	0.18	0.37	0.42	0.18	0.08	0.07
<14 DIM	8	14	20	46	84	24	11	10
14-21 DIM	3	5	5	8	10	5	2	1
22-28 DIM	1	1	4	7	7	3	2	1
29-35 DIM	0	1	2	4	5	1	0	0
>35 DIM	0	0	2	4	3	0	0	0
Total Outliers	12	21	33	69	109	33	15	12

[1] Herd milking 915 cows, milked 2 times daily for 20 consecutive milkings (10 days) calibrated daily meters and representing 18,461 individual milk yield observations.

Table 3. Distribution of potential outliers in herd milked three times daily[1].

	Expected Milk Yield, Adjusted for Herd Effect							
	<65%	<70%	<75%	<80%	>120%	>125%	>130%	>135%
Observed, n	9	21	27	45	53	17	13	11
Observed, %	0.04	0.10	0.13	0.22	0.26	0.08	0.06	0.05
<14 DIM	9	15	19	29	43	13	11	10
14-21 DIM	0	2	2	3	11	2	1	1
22-28 DIM	0	3	4	6	5	1	1	0
29-35 DIM	0	1	1	2	1	0	0	0
>35 DIM	0	0	1	5	4	1	0	0
Total Outliers	9	21	27	45	64	17	13	11

[1] Herd milking 685 cows, milked 3 times daily for 30 consecutive milkings (10 days) calibrated daily meters and representing 20,672 individual milk yield observations.

Animal ID, DIM, milking stall ID, milk yield, milking number ID and date for the defined number of consecutive milkings are the variables required to provide a computerized solution, there are other data points to consider for inclusion in the report. Identification errors, string or pen ID, milking speed, incident reports such as manual milking mode, reattachments or milk flow rates, and average milking time can provide useful metrics for interpretation of the deviations on the computerized solution report and to improve milking center efficiency.

Practical application by the recording organization

Computerized milking system solutions or parlor performance reports offer many advantages to both the dairy owner and the milk recording organization. When all inputs are available and linked, these reports are flexible, cost-efficient and provide more periodic monitoring of the milking system. One of key advantages of the computerized solution report for daily meters is that this report is size-neutral. Provided that previously identified data points are available, this report can provide estimates of stall deviations for herd with as few as four milking stalls (eight is a recommended minimum to ensure adequate data points for calculation of estimates). There is no limit to the maximum number of milking stalls that may be included, nor is there a limitation based on physical location(s). Achieving a meaningful report is possible for herds with multiple parlors operating under the same herd code designation. Further, with programming, herds with groups or strings of cows milking at different frequencies can be included without confounding the estimate of milking stall deviation.

When compared to the time and costs associated with an annual water test calibration, the computerized reports offer a low-cost alternative to monitor the performance of the milking system. These reports can be generated as frequently as daily to provide the herd owner with a system performance check or on every recording day by the milk recording organization to provide a check of data accuracy or conformity prior to acceptance of data into official programs. Some milk recording organizations may find this periodic report more

reliable than the annual water test due to availability to validate each milk yield data upload. While each organization may elect to choose an interval that complies with specific certification requirements, the computerized solution report should be evaluated at least annually provide assurance of the validity and accuracy of the data included in recording programs.

As with any system monitoring report, limitations exist. The primary limitation of the computerized solution for milking stalls is that the report cannot clearly identify if the daily meter itself is operating within stated tolerances. Rather, it identifies that one or more of the components of the milking system in Figure 4 is not in compliance. Intuitive interpretation of the reports is necessary to identify operational failure(s) in the system. By reviewing the reports on a more periodic basis and addressing issues such failing controllers, ID errors, or data transfer concerns, accuracy of data recorded on a daily basis is increased. It should also be noted that any computerized report does not replace the need for required maintenance of milking system components. Finally, it is recommended that if more than 20% of the meters represented are noted as outside the accepted deviation range on a computerized report, the milking system should conduct a water test by a qualified manufacturer's service entity.

Conclusions

Changes in herd dynamics coupled with the application of technology in the milking system have and will continue to impact the service model of milk recording organizations. The shift from monthly meters owned by the recording organization to daily meters owned by individual dairies presents unique opportunities and challenges to the recording organization. When data is automatically recorded by dairies without recording organization supervision, the accuracy of the data should be validated prior to acceptance and use by official organizations. Implementation of a standard computerized milking system solution reporting system provides a frequent, low-cost, and reliable assurance of data validity for the milk recording organization and a system monitoring tool for the dairy operator. Though limitations exist, the advantages of more periodic monitoring of data quality benefit the dairy herd database.