Applied Nutrient Delivery

Richard J. Norell[1]

Department of Animal and Veterinary Science, University of Idaho

INTRODUCTION

The feeder's job description can be summarized as "Getting the right feeds to the right cows at the right time in the right amounts and in the right physical form". The feeder provides the bridge between the ration on paper and the ration presented to the cows. Exemplary effort and performance by the feeder can result in superior herd performance, high feed efficiency, improved hoof health and low incidence rates for metabolic disorders. Exemplary performance doesn't just happen; rather it is driven by effective training, motivation, and communication between the key players on the dairy feeding team (herd owner, herd nutritionist, and feeding crew).

This paper focuses on developing and fine-tuning standard operating procedures (SOP's) for feeders on commercial dairy operations. Well-written standard operating procedures provide direction, improve communication, reduce training time, and improve work consistency (Stup, 2001). Grusenmeyer and Maloney (2000) list 15 additional benefits for developing SOP's (shown below).

"SOP's provide:

1. A guide for relief workers filling in during vacations, illness or turnover.
2. A reference for employee training, cross training and retaining.
3. Less chaos and confusion when employees leave.
4. Consistency. A job is performed correctly every time.
5. Approved procedures reduce the risk of job failures and interruptions.
6. A basis for effective performance evaluation.
7. Improved acceptance of practices because people support what they help create.
8. A means for everyone to think through the whole process of a task.
9. A statement of who does what, where, why and how.
10. Legal protection since a detailed process is documented.
11. Reference document in accident investigations.
12. An opportunity to build unity around attainable standards and goals with procedures to achieve them.
13. An evaluation of labor efficiency and procedural correctness
14. A checklist for co-workers to observe performance and reinforce it if it's correct.
15. An aid in writing job descriptions and identifying skill requirements."

[1] Contact at: Idaho Falls R&E Center, 1778 Science Center Dr., Idaho Falls, ID 83401, 208-529-8376, Fax 208-522-2954, E-mail: rnorell@uidaho.edu

SOP's can take considerable time and effort to develop. Yet they can have very high value for attaining consistency in feeding cattle. They can build a sense of teamwork and a sense of order about the job at hand. Once developed, they need to be implemented and evaluated with revisions as needed.

WHAT DOES A FEEDING SOP LOOK LIKE?

An example SOP for feeding dairy cows is shown in Figure 1. This hypothetical SOP was developed by Richard Stup from Penn State University. He has developed an excellent guide for writing SOP's that is available on the web (Stup, 2000).

In the example SOP, the feeding process in subdivided into four categories: prepare feedbunk, load mixer, mix feed, and distribute feed. Each category has three to five specific instructions. In the prepare feedbunk section, the feeding crew has decided how they will clean the bunk, how they will handle the orts, where they will record the amount of orts, and the target animals to receive the orts. In the "load mixer" section, the crew has identified their resource for determining batch size (feeder notebook), feed loading sequence, and the required records to keep. In the "Mix feed" section, the crew has agreed to mix the TMR for a specified period of time and to record the total weight of the load in the feeder notebook. In the final section, the feeding crew plans to distribute the TMR evenly along the feed bunk, record time that feed was delivered and return the mixer to the equipment shed.

Five specific items can be monitored with the data collected under this example SOP. Amount of feed offered, amount of feed consumed, and orts are all available from the feeder's notebook. Loading accuracy can be assessed by comparing the amount of each feed loaded into the mixer versus the amount scheduled to be loaded. Finally, the consistency of feed delivery can be monitored by observing trends in feed delivery times.

The herd owner benefits from this SOP by having written directions for training new employees, by having objective measures for evaluating feeding crew performance, by collecting appropriate data for assisting the herd nutritionist in monitoring herd performance, by more consistent feeding of the TMR, and by collecting data for tracking feed inventories to potentially minimize shrinkage losses. The feeding crew benefits by having input in developing/revising the SOP, by having clear directions for conducting the feeding operation, and by collecting data that demonstrates superior job performance.

The example SOP provides a good template for developing SOP's on commercial dairy operations. Obviously TMR feeding is different on large western dairies than on a typical northeastern dairy. The remaining portion of this article outlines areas to be discussed when refining or developing a SOP.

DETERMINING BATCH SIZE

The feeder must determine the correct batch size to prepare at each feeding. Providing guidance can ensure that the feeder makes appropriate adjustments in batch size. Making proper feed calls is important for optimizing feed intake and keeping orts to an acceptable level. Key questions to address in the SOP:

Communicating group size? The number of cows within the group is a primary determinant of batch size. Changes in group size need to be communicated to the feeder in a timely fashion, particularly for sensitive ration groups such as close up dry cows and the fresh pen.

How and when to read the feedbunk? The second primary determinant of batch size is the amount of feed remaining in the feedbunk. Several bunk scoring systems are available to guide the feeder's decision. An example scoring system, by Batchelder (1998), is shown in Table 1. The scorecard has a range from 0 to 5 in bunk scores, provides a description of each bunk score and lists recommended ration adjustments based on the feedbunk score. The scorecard assumes the bunks are read one hour before feeding. This scorecard can easily be modified to match goals for the individual dairy. Cautionary advice could be added to reflect further evaluation steps before increasing/decreasing batch size such as reviewing the amount of feed offered during the previous 3 to 4 days, trends in feed intake and associated changes in bunk scores (Skidmore, 2001).

What is the targeted level of orts? A common recommendation is to target leftover feed amounts at 4 to 5%. Feeding for a lower level of orts can lower feed costs and reduces the amount of material that must be managed by the feeder (Barmore, 2002). However, feeding for 4 to 5% refusals provides a buffer for small increases in group size or delayed feeding.

When should bunks be cleaned? A common recommendation is to clean feed bunks once daily and weigh the orts.

Decision on handling the orts? The feed remaining in the bunk can range from resembling the original TMR to mere hay stems and corn-cobs or be hot, slimy spoiled material. How should the feeder handle the each situation?

Records to keep? To monitor dry matter intakes, it is necessary to record the amount of feed offered, the amount of orts, and the number of cows in the group. Paper records are an inexpensive yet effective option. Computer software programs (ie, EZ Feed, Feed Watch, and TMR Tracker) automatically record the feed amounts offered by pen and allow entry of orts to calculate intake. While costs are higher to implement, software programs (and associated equipment) frees the feeder from the drudgery of recording and automatically summarizes the data.

MEASURING DRY MATTER OF SILAGES, HIGH MOISTURE FEEDS AND MIXED TMR

Rations are formulated to meet targeted nutrient intakes on a dry matter basis. Feed amounts must be adjusted to reflect changing dry matter content of silages and high moisture feeds. Key questions to address in developing a SOP include:

Who will perform the test? Adherence to a defined testing schedule is more likely to occur if the task is assigned to a specific member of the dairy crew and when management assigns the task a high priority.

Which feedstuffs will be tested? Sampling and testing all high moisture feeds and silages currently in the ration is recommended. Testing the mixed TMR is recommended to assess final ration moisture content, especially important when water is added to the TMR.

When will the testing be done? Weekly testing is commonly recommended for general quality control of the TMR. Testing is clearly indicated when silage pits or bunkers receive direct precipitation or runoff from snow melt.

How will they be sampled? The recommended sampling techniques should be spelled out in the SOP.

Which procedure will be used? Koster moisture testers and microwave ovens are the two most common on-farm procedures. Recently, a nutritionist has recommended the use of food dehydrators for determining dry matters (Jacobsen, 2001). Special plastic trays (fruit rollup trays) are required with the food dehydrator. A comparison between the three methods is shown in Table 2. Equipment purchase costs are highest for the Koster moisture tester and lowest for a microwave. Time to conduct each test is slightly longer for the Koster than a microwave but Koster does not require close attention throughout the test. Food dehydrators have three primary advantages: multiple tests can be run at one time, the dehydrator does not need to be attended during sample dry down, and there is no risk of burning the sample. The two major disadvantages of food dehyrators are: extended time requirements to dry down samples (~4 hours) and extensive, pervasive odor from the samples. For training purposes, the SOP should include a detailed description of how to conduct the on-farm test.

Who will do the calculations? The math is not difficult but the person who performs the calculations must be comfortable doing them.

Quality control procedures for on-farm testing? Dry matter percentages obtained by Koster moisture testers and microwave ovens tend to be higher than conventional laboratory ovens (Barmore, 2002). To my knowledge, there has not been a comparison between dry matters obtained with a food dehydrator versus conventional laboratory ovens. The University of Idaho has conducted a preliminary study that evaluated dry matter determinations from food dehydrators. Mean dry matter concentrations were similar between 50 and 100 gram samples (Table 3). However, when four samples were run at a time (one sample per tray), there was a trend for higher dry matter concentrations on the lower trays. Dry matter concentrations were quite variable with the food dehydrator. Coefficients of variation were 2 to 3 times higher with food dehydrators than the CV's observed by Oetzel et al (1993) with Koster moisture testers or microwave ovens. Splitting samples and comparing results between a commercial laboratory and the on-farm procedure makes sense for quality control purposes when training new workers.

PREPARING THE TMR

The highest priority for the feeder is to properly prepare each TMR batch (Bucholtz, 1999). The primary goals are to achieve consistent rations from day to day and getting the right feeds to the right cows in the right amount and in the right physical form. Key items to discuss in developing a SOP include:

Min/max batch size? Mixer performance can be poor if the batch size is too small and it can also be poor if the mixer is overloaded. Buckmaster (1998), Kammel 1998), and Stokes and Bethard (1999) provide excellent discussions on evaluating mixer size.

Loading sequence? The order of loading feeds into the mixer has been shown to have significant effects on ration uniformity (Rippel *etal*, 1998 and Cannon, 2002). In developing the SOP, list the current order of loading feeds for each TMR. Compare current feed loading order with the mixer manufacturer's recommendations for loading the TMR.

Mixer types have been directly compared at field days in Wisconsin (Huffman (Cited in Hutjens, 2001), Kammel, 2001, and Kammel et al, 1995). Commercial vendors provided mixers and advised on feed loading sequence. Each mixer prepared the same ration but differed in loading order. Mixers were first loaded and then allowed to mix for a set period of time. Recommended loading orders are shown in Tables 4 and 5. Rations had limited amounts of dry hay (<10% of ration dry matter). It is interesting to see the large variation in recommended loading sequence. The Penn State Separator was used to determine particle size distribution in the mixed rations. Differences in particle size distributions were minimal between mixers when loaded according to manufacturer's recommendations.

Mixing time? Managing mixing time is important to prevent under-mixing and over-mixing of the TMR. When monitoring mixing time, it is important to identify the total length of time that the mixer is in operation. Is this time consistent between feeders? There are three distinct times to track: bale processing time, mix time from end of bale processing to addition of last ingredient, and mixing time from loading of last ingredient to unloading at the feed bunk. The length of time required to process hay depends on hay quality, bale size, mixer settings, sharpness of knives, and amount of hay to be processed. Mixer manufacturers typically recommend running the mixer for 3 to 6 minutes after the loading the last ingredient (Kammel, 1998).

Accuracy in loading? Ration composition will obviously vary if feeders are not careful in loading correct amounts of each feedstuff to the TMR. It is impossible for feeders to consistently load exact amounts and we therefore need to establish acceptable accuracy goals (say ± 20 pounds of planned loading rate) and actionable inaccuracy rates. At what point does the feeder need to resize the batch due to overloading an ingredient or aborting the batch? Actionable inaccuracy rate will likely vary due to the feed ingredient and/or ration group.

There essentially three ways for monitoring and tracking loading accuracy: 1) simple “pencil & paper” records, 2) paper records transferred to computer spreadsheets, or 3) special computerized software programs that interact with the feeding system (Barmore 2002). Option three is the most expensive option but it does provide automatic recording and summarization of data. There are ways to avoid detection of overfeeding ingredients with all three options. Integrity of the feeder is an important factor for establishing a reliable monitoring system.

Scale accuracy? Periodic evaluation of the mixer scale is highly recommended. Evaluation is very easy on large dairies with a delivery scale. Simply weigh the mixer empty and weigh it loaded. The delivery scale and mixer scale should yield similar weights. Mobile scales are influenced the levelness of the mixer. Inaccurate weights can occur if the mixer is on uneven ground.

Evaluating the mixing process? Several methods have been proposed for evaluating the adequacy of the mix (Buckmaster, 1998 and Rippel et al., 1998). The two most commonly used methods on farms are visual assessment and particle size analysis with Penn State Separator. Visual assessment is useful for detecting obvious problems with the mixing process. The assessor looks at uniformity of marker feeds such as cottonseed, flaked corn and/or hay stems in the mix. A poor mix will not have an adequate distribution of marker feeds throughout the feedbunk.

The Penn State Particle Size Separator has been revised and a new publication describing its use is available on the web (Heinrichs and Kononoff, 2002). An excel spreadsheet is also available for calculating particle size distribution and mean particle size.

Ration uniformity has been assessed by collecting at least five samples along the feed bunk and determining particle size distribution with the Penn State Particle Size Separator (Rippel et al., 1998, Predgen and Chase, 2002, and Cannon, 2002). Data are summarized by calculating the mean, standard deviation, and coefficient of variation (standard deviation divided by the mean). Guidelines for evaluating the coefficient of variation are shown in Table 6.

A practical example using the coefficient of variation measure is shown in Table 7. A consultant (Tom Cannon, Data Analysis Services, Friendship, NY) evaluated ration uniformity with three different loading sequences and finally reducing the batch size. TMR’s were mixed in a four auger horizontal mixer. The proportion of large particles in the mix was extremely variable with the initial loading sequence. Switching the order of dry hay and dry grains (sequence 2) actually increased the variability in large particle size along the feedbunk. In sequence 3, the order of loading corn silage and haylage was reversed. Variability in particle size with dramatically reduced by sequence 3. Reducing batch size had minimal effect on uniformity obtained with sequence 3.

Predgen and Chase (2002) used the same procedure to evaluate TMR uniformity on five commercial dairies. TMR data was collected on three days for each dairy. Of the 15 prepared TMRs, only one had a coefficient of variation less than 10%. They also noted that particle size was more variable between days than within a day.

Some manufacturers provide detailed troubleshooting guides for mixer operations. An example guide is shown in Table 8 for single screw-vertical mixers. Troubleshooting guides such as Table 8 are very helpful for training workers and for resolving issues with the TMR mix.

SUMMARY

Standard Operating Procedures (SOP) can provide a wide variety of benefits to the dairy operation. The primary focus of this article was how to develop SOP's for feeding the dairy herd. A well-developed SOP is useful for training new workers and evaluating long-term workers. Establishing and implementing a sound plan means that feeders will "Get the right feeds to the right cows at the right time in the right amounts and in the right physical form".

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Clarity Farms Feeding SOP #1, Feeding the lactating cows
Effective Date: October 7, 2000
Developed by Feeding Crew

Prepare Feedbunk	**Load Mixer**	**Mix Feed**	**Distribute Feed**
1. Sweep feed refusals to end of feed bunk	1. Check feeder notebook for amount of ingredients to mix.	1. Mix feed exactly five minutes.	1. Distribute feed evenly along entire length of feed bunk.
2. Scoop feed refusals into TMR mixer.	2. Add protein concentrate from bin #1. Record lbs added in feeder notebook.	2. Do not move tractor while mixer is running.	2. Record time in feeder notebook.
3. Record weight of feed refusals in feeder notebook.	3. Add ground corn from bin#2. Record lbs added in feeder notebook.	3. Record total amount of feed in mixer in feeder notebook.	3. Return tractor and mixer to equipment shed.
4. Distribute feed refusals in bunk at steer pen.	4. Add corn silage from bunker #1. Record lbs added in feeder notebook.		
	5. Add haylage from bunker #2. Record lbs added in feeder notebook.		

Figure 1. Example Standard Operating Procedure (Source: Stup, 2001)

Table 1. Bunk Scoring System.

Score	Description
0	No feed remaining in the bunk
1	Most of the feedbunk devoid of feed Scattered bits of corn cob from corn silage Few stems from hay present
2	Less than one inch of feed across bottom of bunk Feed looks similar to delivered TMR
3	Two to three inches of feed across the bottom of the bunk
4	More than 50% of the feed remaining from last delivery
5	Feed virtually undisturbed and > 90% remaining

Interpretation:
0 = A score of 0 one hour before the next feeding means increase TMR by 5%
1 = A score of 1 one hour before feeding means increase the TMR by 2 to 3%
2 = A score of 2 one hour before feeding means no change is needed
3+= Investigate the problem and adjust according

Source: Batchelder (1998)

Table 2. Comparison between three on-farm methods for determining dry matter.

Variable	Koster	Microwave	Dehydrator
Cost of equipment	$285[a]	$50	$85[b]
Scale (500g, 0.1g accuracy)	$90	$90	$90
Minutes/test	25 to 30	15 to 20	240
Multiple samples?	no	no	yes
Attendance during test?	+	+++	none

[a]Cost includes Koster moisture tester and a spring loaded scale.
[b]Cost includes the food dehydrator and three additional fruit rollup trays.

Table 3. Comparison of DM determinations with a food dehydrator using two forages, two sample sizes, and four trays per dehydrator (Norell, unpublished).

	Alfalfa Silage			Corn Silage		
Sample	Mean	Range	CV	Mean	Range	CV
50 g[a]	31.1	27.2 to 33.9	6.1	30.6	28.6 to 32.6	3.9
100 g[a]	31.3	28.6 to 35.3	6.4	31.6	29.8 to 34.6	3.8
Tray						
1[b]	29.9	28.0 to 33.0	5.3	31.0	28.8 to 33.3	4.1
2[b]	30.1	29.1 to 32.0	5.0	30.9	28.6 to 34.6	6.1
3[b]	31.1	30.1 to 32.2	1.9	31.0	29.5 to 32.6	3.7
4[b]	33.6	31.5 to 35.3	4.0	31.6	29.8 to 32.6	2.9

[a]n=16 per sample size.
[b]n=8 per tray.

Table 4. Feed loading sequence by mixer type.

	Loading Sequence				
Mixer	Haylage	Corn Silage	Hay	Protein Supp	Corn
Reel Auger+ hay kit	3	4	1	5	2
Reel auger	2	3	5	4	1
Auger	3	4	1	5	2
Vertical	4	5	1	2	3
Auger	4	1	2	5	3

Source: Huffman (cited in Hutjens, 2001).

Table 5. Manufacturer's recommended feed loading order by type of mixer.

	Loading order			
Mixer type	Hay	Silage	Grain	Mineral
Vertical mixers	1	2	4	3
(n=5)	1	2	3	4
	1	2	3	4
	1	4	3	2
4-auger horizontal	2	4	1	3
(n=3)	3	4	1	2
	3	4	1	2
3-auger horizontal	2	3	1	4
(n=2)	2	4	1	3
Reel mixer	3	4	1	2
(n=2)	3	4	1	2

Source: Kammel (2001).

Table 6. Coefficient of variation ranges and interpretations.

CV Range	Interpretation
<10%	Satisfactory
10-25%	Needs improvement
>25%	Cause for concern

Source: Behnke (1996).

Table 7. Effect of loading order on particle size distribution.

		Penn State Separator Pan		
Load Order[1]	Variable	Top	Middle	Bottom
1 (G-H-CS-HYL)	Mean	19.8	42.5	37.4
	SD[2]	5.2	5.1	4.8
	CV[2]	26.1	12.0	12.8
2 (H-G-CS-HYL)	Mean	19.3	44.0	37.1
	SD	5.8	3.0	3.3
	CV	30.3	6.9	9.0
3 (H-G-HYL-CS)	Mean	16.9	47.2	35.8
	SD	1.6	2.8	2.7
	CV	9.6	6.0	7.5
4 (smaller batch)	Mean	18.8	45.3	34.2
	SD	1.9	1.3	2.9
	CV	10.4%	3.0%	8.5%

[1]G = dry grains, H = chopped hay, CS = corn silage, HYL = haylage.
[2]SD = standard deviation, CV = coefficient of variation.
Source: Cannon (2002).

Table 8. Example troubleshooting guide for a single auger vertical mixer.

Condition	Cause	Correction
Hay boils over top	Unit overloaded	Decrease batch size
	Restrictor plates set in to far	Adjust restricter plates
Hay floats on top of mix	Hay not loaded first	Adjust loading order
	Bale not processed enough before adding other commodities	Process until core of bale comes apart
	Restrictor plates in too far	Adjust restrictor plates out
Uneven mix	Insufficient mixing time	Increase mixing time
	Incorrect feed loading order	Adjust loading order
	Restrictor plate in too far	Adjust restrictor plates out
Forage particle size too short	Overprocessing of forage	Faster loading of commodities
		Decrease tractor PTO speed
		Remove some knives
Forage particle size too long	Underprocessing of forage	Adjust restrictor plates in one notch
		Increase tractor PTO speed
		Make sure hay is added first
		Process hay longer before adding other commodities
		Add one more knife to the auger

Source: Supreme International, Wetaskiwin, Alberta