Designing Feeding Facilities to Maintain Feed Quality

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Introduction

Feeding facilities associated with commercial dairy farms should provide an efficient and economical method to produce high quality total mixed rations (**TMR**) for the dairy herd. It is important that feed quality be preserved and shrink minimized from delivery of the feedstuff to the farm until it is placed in the bunk for consumption by the herd. Feed quality can be defined in many different ways. Many times, feed quality is associated with nutrient composition. While extremely important to dairy nutrition, nutrient composition is only the start of defining feed quality. Feed quality factors also include consistency, particle length, anti-quality factors, texture, odor, taste, and temperature. Of the feedstuffs on the dairy, wet products are generally the greatest source of variation and have the greatest potential to reduce the quality of the TMR. Feeding facilities should be designed in a manner to maximize the quality of the TMR by effectively minimizing factors that would reduce TMR quality. One of the major issues with reduced feed quality is associated with shrink of wet feedstuffs. As wet feedstuffs shrink, feed quality is often reduced due to the impact of bacteria, yeast, molds, and moisture loss. Nutrient loss and the increase in anti-quality factors associated with shrink often result in significant losses of production in addition to the economic losses often associated with physical loss of dry matter (Brouk, 2009).

Economic Impact of Shrink

The loss of feedstuffs during storage can be a significant economic issue for dairy farms. Currently, equipment and software are available to dairy farms to effectively track and determine feedstuff shrink. Systems allow producers to accurately record on a daily basis the entrance of feedstuffs onto the farm and the utilization of feedstuffs in TMR mixes. This combined with simply monthly feedstuff inventory adjustments can provide an operation with an efficient way to track feedstuff utilization and the shrink associated with various types of feedstuffs stored in various structures on the farm. These data are very valuable in determining areas of concern, as well as providing economic data necessary to guide future capital investment decisions. Table 1 demonstrates the increase in feedstuff cost as it enters the TMR mixer due to shrink occurring during storage on a dairy farm. For example, if soybean meal is purchased for $300/ton and there is a 5% loss of material during storage, then the cost of soybean meal in the ration increases by $15/ton. If the farm is feeding 5 lb/head/day of soybean meal to 250 cows, then the total annual loss associated with soybean meal would be $3,422 or a 3.75 cent increase in daily per cow feed cost. It is also important to consider that cheaper feedstuffs like corn silage at $50/ton are often fed in greater daily amounts. If corn silage is valued at $50/ton and has a total shrink of 16%, the annual loss associated

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with feeding a 250-cow herd 30 lb/cow day would be $21,900. This would amount to a daily loss per cow of 24 cents. If one considers all the feedstuff shrink on an operation, it is not unusual to find a daily per cow savings of more than 50 cents. With the decrease in margins on dairy operations, determining how to minimize these losses becomes an important management decision.

Storage Structures

Decisions concerning the type of storage structure needed are first dependent on the type of material and then the amount of minimal shrink. Wet feeds and silages obviously require a different structure than dry feeds. The bulk density or physical form of dry feeds may also determine the type of storage structure required. Feedstuffs like whole cottonseed must be stored in flat storage rather than bins. After considering moisture and physical form, the next factor considered is the acceptable amount of shrink associated with different types of feedstuff storage. Data contained in Table 2 demonstrates the amounts of shrink associated with different types of feed and feed storage facilities. For many feedstuffs, enclosed bins result in the least amount of feed shrink. However, filling and unloading this structures requires augers or additional feed handling equipment. Depending on the equipment, the rate of delivery may increase feed mixing time or reduce the access to the feed mixing area while bins are refilled. If bins are utilized, it is possible to design the feed delivery on one side of the bins and the refilling area on the opposite side of the facility. This would allow feed mixing to continue while bins are refilled. Utilization of appropriately sized bin unloading equipment can also reduce the time to deliver ingredients into the TMR mixer.

In some cases, producers may choose to utilize enclosed bins for complete grain mixes that are delivered to the farm. This reduces the number of feedstuffs that need to be inventoried on the farm and can reduce errors associated with loading individual feedstuffs into the TMR wagon. Purchasing individual feedstuffs to be delivered and mixed at the farm is not always the most economical when one considers the cost of shrink, inventory, and additional on-farm mixing time required to blend feedstuffs into the TMR. Some producers have discovered considerable savings and have chosen to buy grain mixes that are delivered directly from the feed supplier ready to be directly incorporated into the TMR.

Once feedstuffs are placed into a 3-sided commodity shed, it is often assumed that the feed is well protected. However, moisture can enter the open front of the bay. As shown in Table 3, significant amounts of moisture can enter the facility. It shows the amount of rain entering every linear foot of a commodity shed assuming 1 inch of moisture blows into a bay for different side wall heights. For example, for a commodity shed, with a 24 foot high sidewall, 15 gallons of water per linear foot will enter a bay. If a curtain is dropped to reduce the opening to 8 feet (skid steer height), then 10 gallons of moisture are prevented from entering the bay, or a 67% reduction. A 50% reduction occurs if a curtain is dropped leaving a 12 foot (pay loader height) opening. Lowering a curtain or flexible door at night or upon completion of feeding may prevent significant ingredient losses due to rainfall and subsequent spoilage. Frequency of rainfall events would determine curtain management and frequency of lowering. Curtains also minimize the impacts of wind and potential movement of ingredients between bays without solid dividers. Buildings for storing commodities delivered in live bottom trailers may be able to reduce the sidewall height to a 14 foot opening using permanent materials.

Storage structures which leave feed exposed to the elements will result in increased losses. The length of storage will also impact shrink. Feedstuffs utilized in a few days compared to those stored for several weeks will generally have reduced storage losses. Increased feed moisture will also increase feed loss due to increased storage time. Enclosed storage should be considered for feedstuffs held more than a couple of weeks.

Figure 1 provides an illustration of a windbreak around a feed center. The windbreak should be located at least 4 times the height of the windbreak away from the feed center. This space will serve as a snow dump area. If snow is not an issue, the windbreak may be located closer to the feed center. "L" shaped commodity sheds provide protection from the wind from multiple directions. Feed center protection is increased if the building is oriented such that the prevailing wind is perpendicular to the intersection of the two building sides (corner of "L") than along one side. A single row of commodity bays may be modified along one side to include a 2nd building to provide additional wind protection. Many dairy farms also need a place to store additional commodities, ground hay, or daily silage needs prior to feeding.

Figure 2 provides an illustration of a totally enclosed commodity building. The advantage to this building is that weather related shrinkage losses are minimized. The overall building width is typically 60 to 80 feet wider than a 3-sided commodity building. This is necessary to provide room inside the building to maneuver semi-trucks delivering ingredients. The authors recommend consulting with trucking firms to make sure there is adequate room. Significant reductions in open space may increase feed loading time since feed loading equipment may not have free space to maneuver rapidly.

Figure 3 illustrates a feed center with a stationery mixer. There is room around the mixer to use micro ingredient tanks, as well as liquid tanks. Stationery mixers enable more hopper bottom tanks with automated handling equipment to be utilized for low inclusion rate ingredients and liquids. Commodity bays are in close proximity of the stationery mixer, allowing adequate time to secure individual ingredients. Another advantage is minimum losses due to weather shrinkage.

Stationary mixers provide an added advantage in limiting the number of people loading the TMR mixer on larger operations. Reducing the amount of TMR variation associated with errors in adding feed to the TMR may be reduced if only one to two people are preforming this task. Stationary mixers also may increase the efficiency of feed delivery equipment and reduce the variation associated with mixing. Often, mixing time is associated with total delivery time. There can be 10 to 15 minutes difference in drive time from the feed mixing area to different pens. This can result in over or under mixing of the TMR. With stationary mixers, the TMR is not mixed on the way to the pen.

When designing feedstuff storage, it is important to consider the rotation of feedstuff inventory. Even vertical bins need to be completely emptied on a regular basis prior to refilling with feed. Therefore, it is important to design with extra bin capacity to accommodate this activity. In flat storage, bay width is often increased to 24 to 30 ft to allow newly delivered feed to be placed next to the existing feed. This eliminates the need to remove existing feed to allow newly delivered feed to be placed behind existing feed in narrow bays.

Correctly formulated TMR is dependent on the accuracy of the weighing equipment utilized in the process. With digital readouts, it is often assumed that the numbers visible on the readout are the exact amount of feed in the mixer. All scales have a range of accuracy. Often, even when correctly calibrated, a scale has an allowable variation of 1% of the weight. Thus, an actual variation of 10 lb on a 1,000 lb reading would be within the range of performance of the scale. Regular maintenance and calibration of weighing equipment should be part of the standard protocols for any dairy. Servicing scales on a regular basis can improve the accuracy of the feed weighing process and improve the consistency of the TMR.

In addition to the maintenance of the scale, it is important to maintain the TMR mixer. Knives and wear points within the mixer need to be changed on a regular basis. Too often these items are forgotten and the result is poorly processed forages and inadequately mixed TMR. Often, when this is discovered, repairs and adjustments are made. However, usually mix times have been increased to account for the worn equipment. These times are not reduced when the new knives are installed. The result is overmixed rations and too much forage particle size reduction. Regular maintenance of the mixing equipment is important in producing high quality TMR.

Technology continues to advance in the area of feed mixing equipment. Today, there are options that allow individual feedstuffs to be weighed, loaded into a TMR mixer, mixed, and then delivered to the feedbunk by automated equipment. Commercial feed mills have utilized this type of equipment for decades. When correctly calibrated, these systems are capable of weighing feedstuffs with much greater accuracy than the conventional loader and TMR wagon. Systems also reduce the amount of time required to mix and deliver feed. If feeds are weighed into a hopper while one load of feed is being delivered to the pens, then the batched feed is simply dumped into the TMR wagon in a matter of a couple of minutes as compared to 12 to 15 minutes of time spent loading individual ingredients. When considering automated systems for larger dairy farms, handling large volumes of forages and other feedstuffs is a challenge. However, future advances in technology and systems will overcome these issues.

Silage Storage and Management

Mold, yeast, and heat are major issues with silage quality. Mistakes during harvest and storage are often compounded by issues during feeding. Often, silages harvested with too little moisture are spoiled prior to incorporation into the TMR. Once incorporated into the TMR, the spoilage continues and quality of the whole TMR is reduced. Whitlock et al. (2000) demonstrated that feeding even low levels of spoiled silage to steers reduced animal performance, intake, and digestibility. The heat produced by secondary fermentation is the transformation of feed energy and nutrients into wasted heat energy. Losses associated with heating of the silage face are determined by the density of the face, moisture of the silage, fermentation of the silage, and the rate of removal. Today, producers are encouraged to remove a minimum of 8 to 12 inches of material from the face of the silo each day to minimize the effects of secondary heating. Correctly designing silage storage, piles or bunkers, to match the daily feeding rate of the herd is often not adequately considered. As a result, silages faces are exposed for a greater number of days, and animals may be fed spoiled feed.

Silages need to be delivered to the feed mixing area daily. Using a loader for this operation will likely result in forage being spilled from the silage storage to the feed center.

Losses are minimized if the silages are loaded and hauled to the feed center. During this operation, it is advised to premix the silage by using a silage de-facer to remove the amount of packed forage needed for the day. Silage de-facers are important in maintaining silage face density and keeping the face vertical as compared with using a loader bucket.

Key Performance Indicators

Feed represents approximately 50% of the total cost of a dairy operation. Feed quality is directly related to milk production. Yet, on most dairy farms, there are a few key performance indicators (**KPI**) that are associated with feed. A list of goals for the feed center might include:

- Minimize feed loss,
- Minimize TMR variation,
- Minimize labor and energy,
- Uniformly mix TMR,
- Uniformly process forage,
- Monitor mixing and delivery accuracy,
- Track feedstuff inventory, and
- Monitor nutrient content and feedstuff quality.

On other aspects of the dairy operations, KPI are often utilized to track the progress of the dairy in relationship to stated goals. When considering the importance of the feeding operation, very little time and effort is expended in developing KPI to evaluate this area. Utilizing feed management software, TMR audits, and feedstuff nutrient analyses can be easily utilized to develop KPI to address the goals stated above.

Conclusions

Feed center design should focus on delivering high quality TMR to the dairy herd. Correctly designed facilities should minimize feed loss while providing adequate space for efficient feed mixing. Dairy farms should utilize available software and technology to accurately track the movement of feedstuffs on the farm and to assess the losses associated with current facilities and management. Data obtained from tracking feed shrink could be utilized to justify capital expenditures for additional equipment or changes to the feed center and associated feed storage. When considering changes to existing feed centers or the design of new feed centers, it is important to consider recent advancements in technology and automation. These advancements may help reduce shrink and increase the accuracy of TMR mixing.

References

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Table 1. Impact of shrink percentage on the cost of feedstuffs and the estimated annual loss of a 250-cow herd feeding 5 lb of an ingredient.

Price, $/ton	$50		$100		$150		$200	
Shrink, %	Increased Cost $/Ton	Annual Loss*	Increased Cost $/Ton	Annual Loss*	Increased Cost $/Ton	Annual Loss*	Increased Cost $/Ton	Annual Loss*
1	$0.50	$114	$1.00	$228	$1.50	$342	$2.00	$456
3	$1.50	$342	$3.00	$684	$4.50	$1,027	$6.00	$1,369
5	$2.50	$570	$5.00	$1,141	$7.50	$1,711	$10.00	$2,281
8	$4.00	$913	$8.00	$1,825	$12.00	$2,738	$16.00	$3,650
12	$6.00	$1,369	$12.00	$2,738	$18.00	$4,106	$24.00	$5,475
16	$8.00	$1,825	$16.00	$3,650	$24.00	$5,475	$32.00	$7,300
20	$10.00	$2,281	$20.00	$4,563	$30.00	$6,844	$40.00	$9,125
Price, $/ton	$250		$300		$400		$800	
Shrink, %	Increased Cost $/Ton	Annual Loss*	Increased Cost $/Ton	Annual Loss*	Increased Cost $/Ton	Annual Loss*	Increased Cost $/Ton	Annual Loss*
1	$2.50	$570	$3.00	$684	$4.00	$913	$8.00	$1,825
3	$7.50	$1,711	$9.00	$2,053	$12.00	$2,738	$24.00	$5,475
5	$12.50	$2,852	$15.00	$3,422	$20.00	$4,563	$40.00	$9,125
8	$20.00	$4,563	$24.00	$5,475	$32.00	$7,300	$64.00	$14,600
12	$30.00	$6,844	$36.00	$8,213	$48.00	$10,950	$96.00	$21,900
16	$40.00	$9,125	$48.00	$10,950	$64.00	$14,600	$128.00	$29,200
20	$50.00	$11,406	$60.00	$13,688	$80.00	$18,250	$160.00	$36,500

*Annual loss associated with shrink percentage when feeding 5 lb of the ingredient daily to 250 dairy cows.

Table 2. Percent loss of different ingredients based on type of storage facility (Kertz, 1998).

Ingredient	Uncovered Open Piles	Covered 3-sided Bay	Closed Bin
Whole Cottonseed	10 – 20 %	5 -15 %	-------
Dry Meal	5 – 10 %	3 – 8 %	2 – 4 %
Soybean Hulls	12 – 20 %	5 – 10 %	2 – 5 %
Dry Distillers	15 -22 %	7 – 10 %	3 – 5 %
Wet Distillers	15 – 40 %	15 – 40 %	-------

Table 3. Amount of water entering a commodity shed per linear foot due to 1 inch rainfall blowing into the open bays.

		Impact of Reducing Opening to 8 feet		Impact of Reducing Opening to 12 feet	
Height of Open Side (feet)	Gallons moisture entering the commodity shed at full opening	Reduction in gallons of moisture entering commodity bays	Reduction as compared to fully open side wall	Reduction in gallons of moisture entering commodity bays	Reduction as compared to fully open side wall
8	5.0	NA[1]	NA	NA	NA
12	7.5	2.5	33%	NA	NA
16	10.0	5.0	50%	2.5	25%
20	12.5	7.5	60%	5.0	40%
24	15.0	10.0	67%	7.5	50%
28	17.5	12.5	71%	10.0	57%
32	19.9	15.0	75%	12.5	63%

[1]NA = Not applicable.

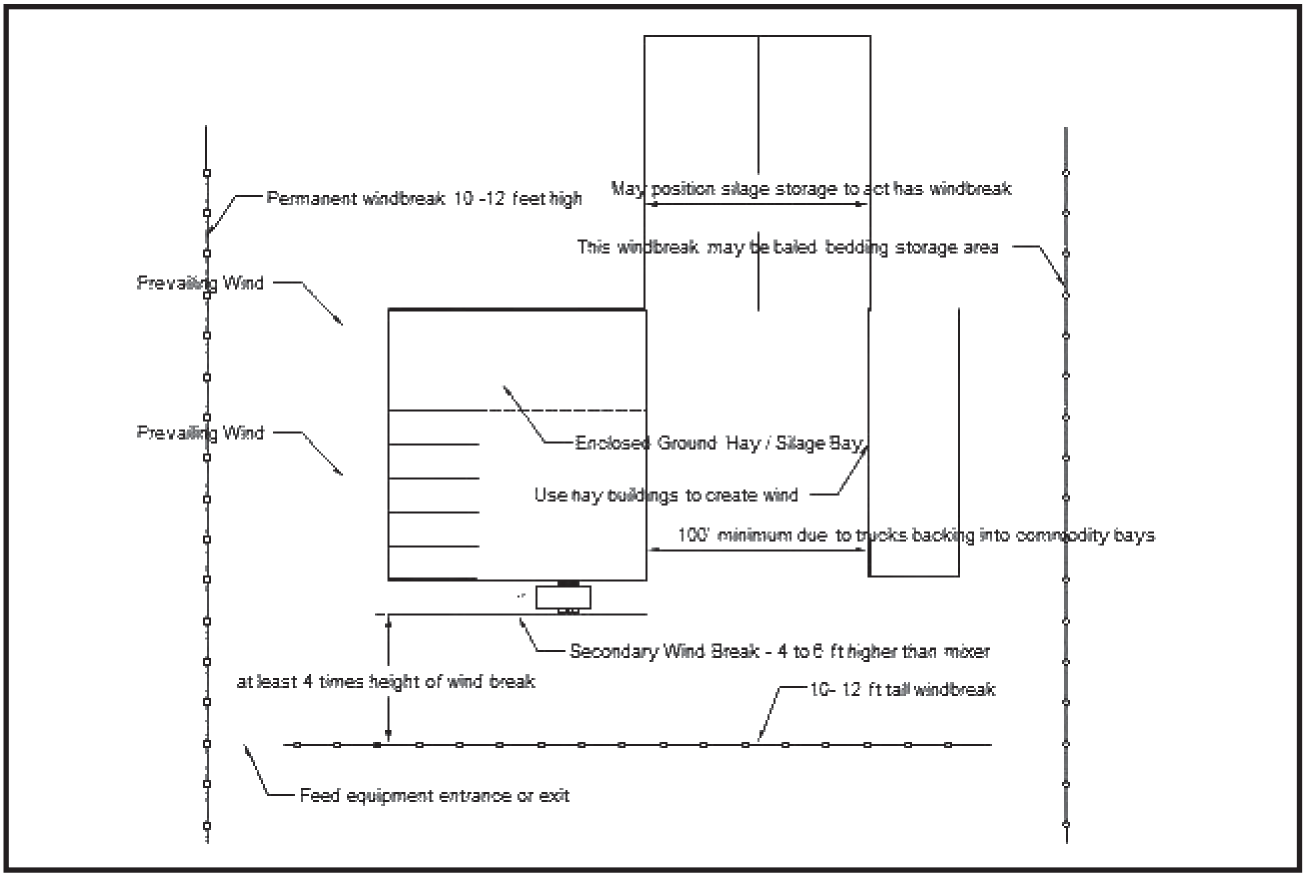


Figure 1. Utilization of buildings and windbreaks to minimize shrinkage due to wind (Harner et al., 2011).

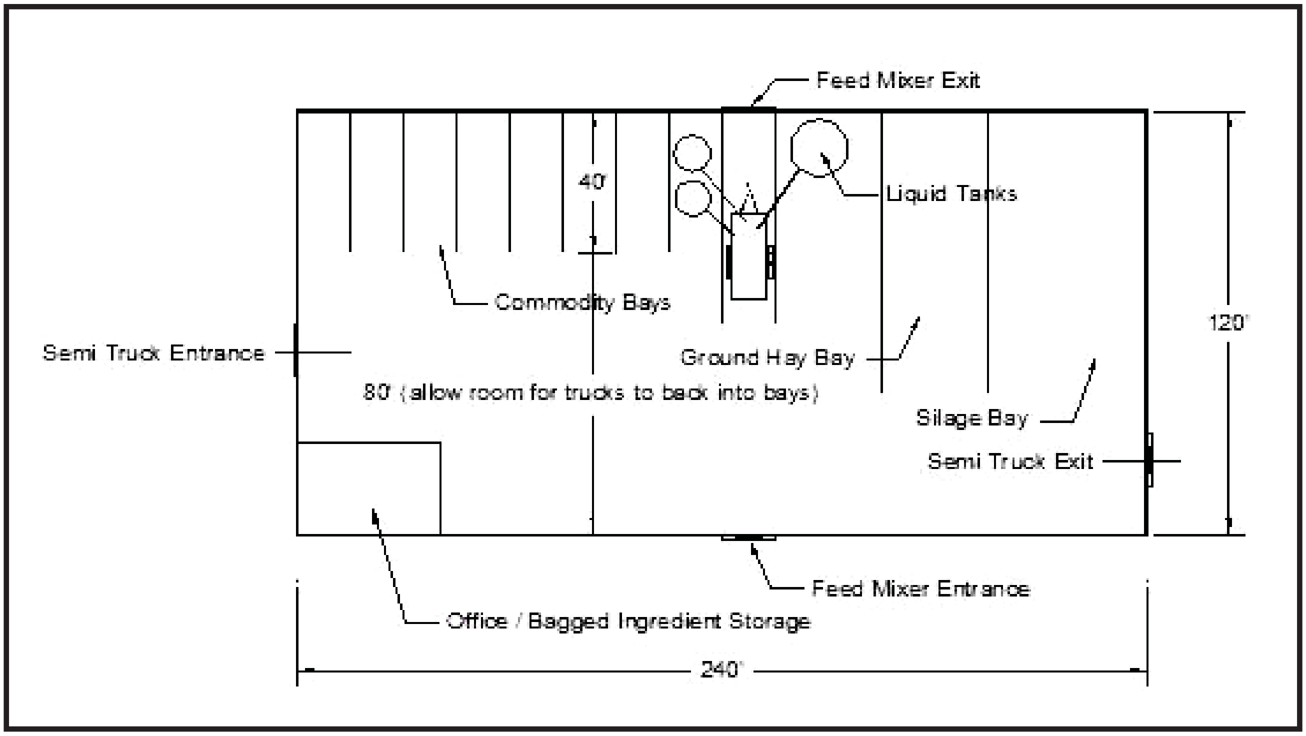
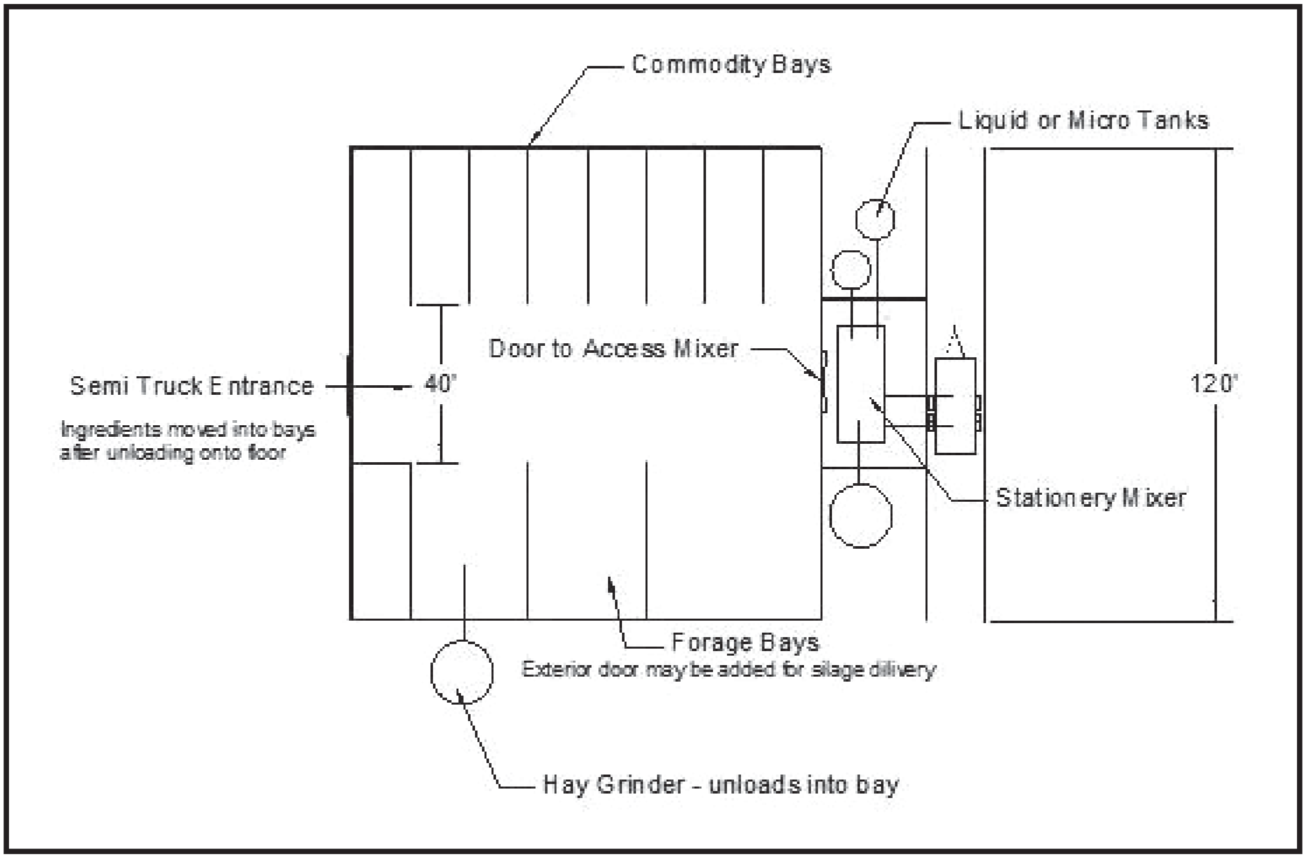


Figure 2. Illustration of totally enclosed commodity building using a portable mixer (Harner et al., 2011).



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