Silage Safety, Shrink and Methods to Control Losses

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Introduction

At the Forage Conservation in the '80s Conference, Zimmer (1980) concluded that the gaps between "proven technology" and "real efficiency" of silage programs on the farm were too wide, too often. Over 35 years later, the silage industry is still faced with the challenge of implementing silage technologies, both old and new. A large segment of this industry is described as the "Silage Triangle". Persons responsible for 1) the animals, 2) the forage, and 3) the harvesting process represent the points of the silage triangle. In some beef cattle operations, one person is responsible for all three points. But in many instances, growing the silage crop and harvesting the crop are done completely on a contract basis, creating a situation where a different person is at each point of the triangle. When communication between the points of the triangle is ineffective, inefficiencies can result that directly affect every phase of the silage program.

Although a beef cattle operation's nutritionist, often an outside consultant, is not a direct part of the triangle, he or she has an obvious vested interest in how well the triangle performs. The nutritionist might be the key person in assuring effective communication between the triangle's three points. The nutritionist's responsibility is generally to the *animal* point of the triangle, so among his or her major responsibilities could be 1) educating the client about proper silage management and 2) fostering effective communication. Ideally, the nutritionist might moderate an annual meeting between the cattle manager, the forage grower and silage contractor, making sure that all involved are on the 'same page' regarding expectations and implementation of the silage program. In other cases, a small cattle producer might be on the wrong end of a tight supply/demand situation and lack the economic power to make demands on the grower and/or the silage contractor. Then, the nutritionist must focus on the producer, and make sure things directly under the producer's control are done right.

From 2012 to 2015 an average of 121.6 million tons of whole-plant corn was harvested annually for silage in the USA (USDA, 2016). Iowa and Nebraska produced an average of 6.11 and 4.60 million tons of corn silage, respectively, during that 4-year period. The amount of silage lost each year as a result of 'shrink', which is defined as tons of crop dry matter (DM) ensiled minus tons of silage DM fed, is too high in too many silage programs. It is estimated that between 16 and 18 percent of the corn silage put up in 2015 will be lost. That is about $1.1 to 1.3 billion in feed inventory. If the 'shrink' were a single digit, the loss would only be about $600 million worth of corn silage. All beef cattle operations could make improvements in their silage program, which would allow them to feed a higher percent of their silage inventory and improve silage quality.

Two silage management practices, packing and sealing, have the potential to decrease DM loss by 5 to 10 percentage units in bunker silos and drive-over piles. Strategies to reach a high silage DM density and to achieve an effective oxygen-barrier seal, and related decision-making software are presented.

Few farming operations invite as many different opportunities for injury or fatality as a silage program. One of these is an avalanche or collapsing silage. It only takes a fraction of a second for part of a silage face to silently break off and fall, and the result can be deadly for anyone located beneath it. There have been numerous avalanche fatalities in the United States the past few years, including an 11-year old boy on a dairy in New Hampshire (WMUR TV, 2010), a 34-year old truck driver on a farm in New Mexico, a 53-year old owner of a feedlot in Nebraska, and a 63-year old employee on a dairy in Pennsylvania

(Bolsen and Bolsen 2014; Bolsen et al., 2015). Although rarely reported, the authors have heard many stories about someone having a near miss or suffering a serious injury in a silage avalanche. Guidelines that can decrease the chance of having a serious injury or fatality caused by a silage avalanche are presented.

Achieving a Higher Silage Density

Silage density and preservation efficiency, measured as DM recovery, are positively related. Higher densities also increase the storage capacity of existing bunker silos (without over-filling) and decrease the height of drive-over piles (without reducing storage capacity). However, in surveys on farms, results show that many producers are not achieving the recommended minimum silage density of about 15 to 16 lbs. per ft^3 (44 to 48 lbs. fresh weight bulk density per ft^3) (Craig et al., 2009).

Case study beef cattle feedlot: bunker silo. The actual first-year corn silage had a DM density of approximately 12 to 13 lbs. per cubic foot. The density was measured at 4 feet above the floor of the bunker, which had an average depth of about 18 to 20 feet. The Holmes-Muck spreadsheet was used to estimate the second-year corn silage density at two forage delivery rates (140 and 280 fresh tons per hour) and one, two, or three pack tractors (Holmes and Muck, 2007). Results are shown in **Table 1.**

The target density for second-year was 16.0 lbs. of DM per ft^3 (48.0 lbs. of fresh weight per ft^3). At a forage delivery rate of 140 tons per hr., two pack tractors would achieve the target (16.9 lbs. of DM and 49.8 lbs. fresh weight). However, the expected forage delivery rate was about 280 tons per hr., and the estimated density would only be 12.5 lbs. of DM per ft^3 (37.6 lbs. fresh weight) with two pack tractors. By adding a third pack tractor, the estimated density was 17.2 lbs. of DM per ft^3 (51.7 lbs. fresh weight), which would exceed the target. But more importantly, the third tractor would lower the height of the feedout face by 1 to 2 feet, without compromising storage capacity, and decrease estimated shrink loss by 3 to 5 percentage points.

Several key considerations to increase silage density, which were first presented by Holmes and Bolsen (2009) at the 15^{th} International Silage Conference, include:

1. Good communication. For example, if forage delivery rate increases at any time during the day, producers must be prepared to add an extra pack tractor.
2. Always estimate silage density before the harvest begins by using spreadsheet software (Holmes and Muck, 2007 and Holmes and Muck, 2008) and be prepared to adjust harvesting, filling and packing procedures.
3. Employ well trained experienced people, especially those who operate the push-up/blade tractor(s). Provide training as needed.
4. When pushing up, take forage from the edge of a load after the truck has moved to a safe distance.
5. Forage should be spread in uniform layers of 6 inches or less, and packing must be done continuously during the entire filling process.
6. Form a progressive wedge of forage and maintain a maximum slope of 1 to 3 (one foot of rise for each three feet of horizontal).
7. The slope can be decreased to 1 to 4, depending on the forage delivery rate and number of pack tractors.
8. Increase the weight of all push-up and pack tractors
9. Abut the pack tractor tire with the track of the previous tractor pass.
10. There should be at least two pack tractor passes over the surface of each layer of forage.
11. Drive-over piles should be packed from side-to-side, as the progressive wedge advances, and the sides of the pile should never exceed a slope of 1 to 3.
12. When two or more pack tractors are used, establish a driving procedure.
13. When possible, drive up and back down packing slopes. Do not drive tractors in a circle and avoid making 180 degrees turns on the floor of a bunker or front apron of a pile.

14. Increase pack tractor passes near the wall of bunker silos to increase the density of the forage that is within three feet of the wall.

Achieving a more effective Seal of Bunker Silos and Drive-over Piles

Bunker silos and drive-over piles, by design, allow a large percentage of the ensiled material to be exposed to the environment. Although polyethylene sheeting, which is typically weighted with discarded car or truck tires or tire sidewalls, has been the common method used to protect silage near the surface for decades, the protection provided is highly variable and often changes during storage (Holmes and Bolsen, 2009). Many cattle producers are quick to point out that putting plastic and tires on bunkers and piles is not an activity enjoyed by their employees.

At the 12th International Silage Conference, an oxygen barrier (OB) film (www.silostop.com) was introduced as an alternative to standard white-on-black polyethylene to seal bunkers and piles. The OB film, which is 45µm in thickness, has dramatically improved the preservation efficiency and nutritional quality of silage in the outer 1.5 to 3 feet in bunkers and piles (Wilkinson and Fenlon, 2013).

Economics of sealing bunker silos and drive-over piles. Excel spreadsheets to calculate the profitability of sealing ensiled forage or high moisture grain in bunker silos and drive-over piles were developed from research at Kansas State University from 1990 to 1995 and equations published by Huck et al. (1997). Examples are shown in **Table 2**. In an 80 feet wide x 675 feet long bunker silo of corn silage, which has an average depth of 16 feet, sealing with OB film would save $59,830 of silage after sealing cost compared to not covering. Sealing with OB film would save a net $10,910 of corn silage compared to sealing with standard plastic.

Silage safety: Avalanches

A silage avalanche can occur anywhere, anytime, in any bunker silo or drive-over pile, without warning, and in any ensiled forage.

At a Pennsylvania State University Forage Focus seminar, several farmers told of close calls while shaving bunker or pile feedout faces that seemed safe but collapsed quickly (Hay and Forage Grower, 2010). One told of the death of a worker, while taking samples. “All three workers went up to the face and they pulled a sample, turned to walk away and the pile just fell away. It hit … two people from the back and knocked them down. The other guy was walking toward the loader and it completely covered him up. We are still having a hard time dealing with that.” After the accident, the farm developed a safety plan. “Our policy is that nobody is allowed closer to the bunker face than the height of the bunker long. No exceptions. If there is a tire there, we will get it later. If there is a forage sample, you better take it with a bucket. We thought that it wasn’t an issue, just like everybody else thought it wasn’t an issue. Then it happened to us. You don’t know what a bunker face is like.”

We cannot stop avalanches from happening, and they are impossible to predict, but we can prevent people from being under them.

Here are guidelines that can decrease the chance of having a fatality or serious accident caused by a silage avalanche.
1. Never allow people to approach the feedout face. No exceptions!
2. A rule-of-thumb is never stand closer to the silage face than three times its height.
3. Suffocation is a primary concern and a likely cause of death in any silage avalanche. Follow the “buddy rule” and never work in or near a bunker or pile alone.
4. Bunker silos and drive-over piles should not be filled higher than the unloading equipment can reach safely, and typically, a large unloader can reach a height of 12 to 14 feet.
5. Use caution when removing plastic or oxygen-barrier film, tires, tire sidewalls or gravel bags near the

edge of the feedout face.
6. Do not remove surface spoiled silage from bunkers and piles that are filled to an unsafe height.
7. Use proper unloading technique, which includes shaving silage down the feedout face.
8. Never dig the bucket into the bottom of the silage. Undercutting creates an overhang of silage that can loosen and tumble to the floor.
8. Never drive the unloader parallel to and in close proximity of the feedout face in an over-filled bunker or pile.
9. When sampling silage, take samples from a front-end loader bucket after it is moved to a safe distance from the feedout face.
10. Never ride in a front-end loader bucket.
11. Never park vehicles or equipment near the feedout face.
12. A warning sign, 'Danger! Silage Face Might Collapse', should be posted around the perimeter of bunker silos and drive-over piles.
13. Avoid being complacent! Always pay attention to your surroundings and never think that an avalanche cannot happen!
14. Every farm, feedlot, and beef cattle operation should have safety policies and procedures for their silage program, and they should schedule regular meetings with all their employees to discuss safety.

Conclusions

Packing forage to higher densities in bunkers and piles will decrease shrink loss and decrease height of the feedout face without decreasing storage capacity. Sealing bunkers and piles with OB film will decrease shrink loss by preventing surface spoilage, which eliminates the need to ask employees to perform a potentially dangerous task. Bottom line. If a silage program is not safe, then nothing else about it really matters. Send all employees home safe … everyday!

References

Bolsen, R.E., and K.K. Bolsen. 2014. Preventing fatalities and serious injuries from silage avalanches. In: *Progressive Dairyman.* Vol. 26, August issue. Pg. 66-67.

Bolsen R.E., M.E. Uriarte, R.F. Andrade, C.C. Banchero and K.K. Bolsen. 2015. Safety issues in large-scale bunker silos and drive-over piles re-visited: avalanches. In: *Proc. 17th International Silage Conference*. Piracicaba, Brazil. Pg. 301-302.

Craig, P.H., K.E. Griswold, and S.K. Dinh. 2009. Six years of corn silage density evaluations in south central Pennsylvania. In: *Proc. 15th International Silage Conf.*, Madison, WI Pg. 223-224.

Hay and Forage Grower. 2010. Producers debate on bunker management. http://hayandforage.com/ecorn-archive/1208-producers-debate-bunker-management/

Holmes, B.J. and R. Muck. 2007. Spreadsheet to Calculate the Average Silage Density in a Bunker Silo: http://www.uwex.edu/ces/crops/uwforage/storage.htm

Holmes, B.J. and R. Muck. 2008. Spreadsheet to Calculate the Average Silage Density in a Silage Pile. http://www.uwex.edu/ces/crops/uwforage/storage.htm

Holmes, B. J. and K. K. Bolsen. 2009. What's new in silage management? In: *Proc. 15th International Silage Conf.*, Madison, WI. Pg. 61-76.

Huck, G.L., J.E. Turner, M.K. Siefers, M.A. Young, R.V. Pope, B. E. Brent, K.K. Bolsen. 1997. Economics of sealing horizontal silos. Kansas Agric. Exp. Sta. Rpt. of Prog. 783:84.

United States Department of Agriculture. 2016. National Agricultural Statistics Service. Corn for silage: 2012-2015. https://quickstats.nass.usda.gov/ Accessed 17 February 2016.

WMUR TV. 2010. Boy buried in feed pile dies. Claremont, NH. Web site accessed August 21, 2010. http://www.wmur.com/r/23258422/detail.html

Wilkinson, J.M. and J.S. Fenlon. 2013. A meta-analysis comparing standard polyethylene and oxygen barrier film in terms of losses during storage and aerobic stability of silage. Grass Forage Sci. 69, 385–392.

Zimmer, E. 1980. Efficient silage systems. Occasional Symposium of British Grassland Society Forage Conservation in the '80s Conference, No. 11: 176-194.

Table 1. Spreadsheet calculations of silage densities in a bunker silo of corn silage for a case study cattle feedlot operation.[1]

Component	1 tractor 140 t/hr.	2 tractors 140 t/hr.	2 tractors 280 t/hr.	3 tractors 280 t/hr.
Bunker silo wall height, ft.	**14**	**14**	**14**	**14**

Maximum silage height above wall, ft.	**3**	**3**	**3**	**3**
Forage delivery rate, fresh tons per hr.	**140**	**140**	**280**	**280**
Forage DM content, %	**33.3**	**33.3**	**33.3**	**33.3**
Estimated forage layer thickness, inches	**9**	**6**	**8**	**5**
Tractor #1	**60,000 (70)**[2]	**60,000 (75)**	**60,000 (75)**	**60,000 (75)**
Tractor #2	**0**	**60,000 (75)**	**60,000 (75)**	**60,000 (75)**
Tractor #3	**0**	**0**	**0**	**60,000 (90)**
Estimated DM density, lbs. per ft^3	11.9	16.9	12.5	17.2
Estimated fresh wt. density, lbs. per ft^3	35.7	49.8	37.6	51.7

[1]Numbers in bold are user inputs. [2]Estimated packing time as a % of filling time in parenthesis.

Table 2. Economics of sealing corn silage in bunker silos with average management practices.[1]

Inputs and calculations	Bunker 1 No cover	Bunker 2 Std. plastic	Bunker 3 Silostop
Silage value, $ per ton 'as-fed'	**50.00**	**50.00**	**50.00**
Density of silage in top 3 ft., lbs. 'as-fed' per ft^3	**40**	**40**	**40**
Silage density below top 3 ft., lbs. 'as-fed' per ft^3	**48**	**48**	**48**
Bunker depth, ft.	**16**	**16**	**16**
Bunker width, ft.	**80**	**80**	**80**
Bunker length, ft.	**675**	**675**	**676**
Silage lost in original top 3 ft., % of crop ensiled	**60.0**	**25.0**	**15.0**
Silage lost below original top 3 ft., % of crop ensiled	**10.0**	**10.0**	**10.0**
Cost of covering materials, ¢ per ft^2	**0**	**4.0**	**12.0**
Total silage in the bunker, tons	20,088	20,088	20,088
Value of silage in the bunker, $	1,004,400	1,004,400	1,004,400
Silage in the original top 3 ft., tons	3,240	3,240	3,240
Value of silage in original top 3 ft., $	162,000	162,000	162,000
Total silage lost in the bunker, % of crop ensiled	18.1	12.4	10.8
Silage lost in the original top 3 ft., $	97,200	40,500	24,300
Silage saved by sealing, $	---	56,700	72,940
Sealing cost, $	---	7,780	13,070
Net silage saved by sealing, $	---	48,920	59,830
Net benefit from Silostop v. std. plastic, $	---	--	10,910

[1]Numbers in bold are user inputs.