

SILAGE SAFETY HANDBOOK

A resource to help you maximize
the value of your forage





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We're delivering specific solutions and service to drive you *Forward*.

SILAGE SAFETY HANDBOOK

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FOREWORD

Every year accidents occur during the process of making and feeding silage, in some cases with fatalities or serious injuries resulting. Many, if not all, of these incidents could be avoided if all individuals involved from harvesting through to feeding were fully aware of the possible dangers and practiced a “safety first” approach. There is often the temptation, as tasks become routine, for complacency to set in: when working around silage, we need to always be vigilant, and be aware of the risks and how to minimize or avoid them.

As a company involved in the agriculture industry, we felt that the industry needed a “Safety 101” primer: a short, simple document to bring home the risk factors, plus some “best practice” recommendations to help mitigate them.

Having decided to produce this handbook, there really was only one choice for authorship: Keith Bolson. Since retiring from Kansas State University after educating a generation of students about the importance of silage as a feed, researching how to produce high quality silages when few others thought beyond just piling it in a heap and letting it sit, and passing on the knowledge to countless producers through seminars and individual visits, Emeritus Professor Keith Bolson and his wife Ruthie have dedicated themselves to spreading the message of making, feeding and working around silage safely. We were pleased when they readily accepted the challenge to produce a safety handbook, and re-committed to this update, to help stimulate awareness and establish some best practice standards. I am personally delighted to have the opportunity to once again introduce the booklet to you and to thank Keith and Ruthie for their excellent work. I hope that you all will enjoy reading it as much as I have during the proofing process. I also hope that the content will make you think more critically about safety around silage, as it did me.

BE INFORMED! BE ALERT! BE AWARE! BE SAFE AROUND SILAGE!

Bob Charley, Ph. D.
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Lallemand Animal Nutrition

**Additional information on factors affecting silage quality
is available on www.qualitysilage.com.**



INTRODUCTION

Few farming operations invite as many different opportunities for injury or fatality as a silage program. From harvesting the forage in the field, transporting it to the farm, placing it into storage and then feeding out the silage, employees are exposed to numerous serious risks.

Silage-related tragedy knows no age boundary as workers and bystanders of all ages have been injured or killed during silage harvest and feedout. Although silage injury statistics are not easily collated, countless stories are told of PTO and harvesting machine entanglements, highway mishaps between farm equipment and automobiles, entanglements in self-unloading wagons and blowers and encounters with silo gas. Increasingly, stories involve bunker silos and drive-over piles.

Consistently protecting employees, equipment and property throughout harvesting, filling and feeding does not occur without thought, preparation and training.

The silage industry has nothing to lose by practicing safety but it has everything to lose by not practicing it.

This handbook presents several common hazards involved with managing silage in bunkers and piles, and the primary ways these hazards can be eliminated, reduced or controlled.



TRACTOR OR TRUCK ROLL-OVER

Tractor rollovers account for about 50 percent of the approximately 200 tractor-related fatalities reported annually in the USA.

- Roll-over protective structures (ROPS) create a zone of protection around the tractor operator. When used with a seat belt, ROPS prevent the operator from being thrown from the protective zone and crushed by the tractor or equipment drawn by it.
- A straight drop off a bunker silo wall is a significant risk, so never fill higher than the top of the wall.
- Sight rails should be installed on above-ground walls. These rails indicate the location of the wall to the tractor operator but they are not intended to hold an over-turning tractor.
- Lights should be installed to the rail if filling at night.
- When filling bunker silos and drive-over piles, pack tractor operators should always form a progressive wedge of forage, which provides a safe slope for packing.
- To reduce the risk of a tractor roll-over, it is very important to maintain a minimum slope of 1 in 3 on the sides and ends of a drive-over pile.
- Tractors should be backed up steep slopes to prevent roll-backs.
- Use low-clearance, wide front-end tractors equipped with well lugged tires to prevent slipping.
- Never use large rectangular or round hay or straw bales for temporary bunker walls.
- Add weights to the front and back of the tractors to improve stability. This will have the added benefit of improving packing efficiency.

- When using front-end loaders to move forage to the bunker or pile, do not carry the bucket any higher than necessary to help keep the center of gravity low.
- When two or more pack tractors are used, establish a driving procedure to prevent collisions.

Figure 1.
Pack tractor operator in dangerous position above the bunker silo wall



Figure 2.
Pack tractor operator in a dangerous position on a steep side-slope of a pile



Large scale beef and dairy operations typically use trucks for transporting chopped forage to the bunker or pile. Here are safety guidelines:

- Trucks can over-turn on steep forage slopes, particularly if the forage is not loaded and packed uniformly.
- Raise the dump body only while the truck is on a firm surface to prevent an over-turn.
- As the bed is raised for unloading, it is important that the load center of gravity stay between the frame rails of the truck frame.
- Trucks become less stable as the bed is raised, particularly if the surface is less than perfectly flat.
- A tire rut or depression from a previous load, low tires on one side of a truck, uneven loading of a truck or a wind gust increase the risk of a truck tipping over during unloading, especially when two or more of these hazards combine at a single point in time.

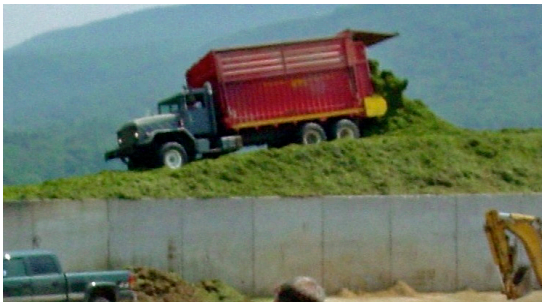
Figure 3.

Two tractor operators working as a team, while packing on a safe 1 to 3 front slope in a drive-over pile



Figure 4.

Silage truck unloading forage in a dangerous position above the wall in a bunker silo



ENTANGLED IN OR RUN-OVER BY MACHINERY

“The accident happened while making silage at Kansas State University’s Research Farm. The blower pipe plugged for about the eighth time that afternoon, and I started to dig forage out from the throat of the blower. The PTO shaft made one more revolution, and the blower blade cut off the end of three fingers on my right hand.”

(Cited by Bolsen and Bolsen, 2006)

- Never repair any machinery while it is running. Always switch off and isolate from the source of power and make sure the machinery has stopped, just as would be required in an industrial environment. Keep machine guards and shields in place at all times. They protect the operator from an assortment of rotating shafts, chain and v-belt drives, gears and pulley wheels, and rotating knives on pull-type and self-propelled harvesters, tractors, unloading wagons and silage feeding equipment.
- Adjust rear view mirrors on all tractors and trucks.
- Install back-up warning alarms.
- Never allow people (especially children) in or near a bunker silo or drive-over pile during filling.



Figure 5.

People walking in drive-over piles during filling

FALL FROM HEIGHT

- Install guardrails on all above-ground level walls.
- Use caution when removing plastic, tires, tire sidewalls and gravel bags from bunker silos and drive-over piles, especially near the walls and edge of the feedout face.
- Use equipment operating from the ground level to remove surface-spoiled silage from the surface of bunkers and piles.
- NEVER allow a person to ride in the bucket of a front-end loader to take samples from the silage feedout face.



Figure 6. An employee standing dangerously close to the feedout face while removing surface-spoiled silage

AVALANCHE OR COLLAPSING SILAGE

Silage avalanches are real and there is no way to predict when and where they will occur. It only takes a fraction of a second for part of a silage feedout face to silently break off and fall, and the result can be deadly for anyone located beneath it.

A 53-year-old Norfolk man died Monday, October 21, 2013 in a feedlot accident. Stanton County Sheriff Mike Unger said Matthew Winkelbauer died after he was buried by a large silage pile that fell in a silage pit at Four-Quarters Feedlot east of Norfolk. Winkelbauer, who was the owner and operator of Four-Quarters, was pronounced dead at the scene. A co-worker was seriously injured in the accident that occurred about 3 p.m.

(Cited by Bolsen and Bolsen, 2014)

It is not uncommon for feedlots and large dairies to have bunkers and piles with silage faces that are 18 to 24 feet tall or taller. Common sense tells us that a 20 to 22 feet tall silage face is far more dangerous than one that is only 10 to 12 feet tall.

Personal communication from a nutritionist on July 22, 2013: "It was March 15, 2010 and I went to see a large dairy farm client. Me and two of the herdsmen went to the large bunker silo (8,000 tons capacity). The height of the feedout face was about 20 feet. After visual appraisal of the silage, we were walking out of the bunker and a large silage avalanche fell on us. Observers later said it was around 10 tons of silage. One of the herdsmen's head remained outside of the silage, and thank God, he could call to other employees to come and save us. The worst injuries happened to me, including multiple fractures in my tibia and femur, and I was in a coma for 30 hours in the hospital. I was the last one rescued, being trapped under the silage for 20 minutes. It is by the grace of God that I am alive."

(Cited by Bolsen and Bolsen, 2014)

We cannot stop avalanches from happening, but we can prevent people from being under them. Here are guidelines that can decrease the chance of having a serious accident caused by a silage avalanche.

- Never allow people to stand near the feedout face. No exceptions!
- A rule-of-thumb is never stand closer to the silage face than three times its height.
- Follow the “buddy rule” and never work in or near a bunker or pile alone. The buddy rule saves lives. Suffocation is a major concern and likely cause of death in a silage avalanche.
- Bunker silos and drive-over piles should not be filled higher than the unloading equipment can reach safely, and typically, an unloader can reach a height of 12 to 14 feet.
- Do not “pitch” spoiled silage. It is simply too dangerous to remove spoilage from the top of many bunkers and piles. Only remove spoiled silage with equipment operated safely from ground level.
- Use proper unloading techniques, which includes shaving silage down the feedout face.
- Never “dig” the bucket into the bottom of the silage. Undercutting creates an overhang of silage that can loosen and tumble to the floor. This situation is quite common when the unloader bucket cannot reach the top of an over-filled bunker or pile.
- Never drive the unloader parallel to and in close proximity of the feedout face.
- When sampling silage, take samples from a loader bucket after it is moved to a safe distance from the feedout face.

- Never park vehicles or equipment near the feedout face.
- When working in or on an over-filled bunker or pile, always wear a harness connected a safety line.
- Wear a safety vest whenever working around silage.
- Always pay attention to your surroundings and never think an avalanche cannot happen!
- A warning sign, ‘Danger! Silage Face Might Collapse’, should be posted around the perimeter of bunkers and piles.
- If a bunker silo or drive-over pile is in a remote area on the farm, then the perimeter of should be fenced and a sign posted, ‘Danger: Do Not Enter. Authorized Personnel Only’.

An 11-year old boy died from injuries suffered after a silage pile collapsed on him at a farm near Claremont NH. Andy Wheeler had previously been listed in critical condition at Dartmouth-Hitchcock Medical Center. Police said it took as long as 20 minutes to find and free Wheeler from the silage pile after the accident. Police said the boy was on vacation from school and was hanging out at the MacGlaflin Farm, where his father works. “The boy was in a silage crib where there was a large pile of silage, and that overhang collapsed,” said Police Chief Alexander Scott. No one was working in the bunker, and no one saw what happened. When Andy was found, an adult started CPR, and he was taken to a hospital. “It’s probably a pile close to 25 feet high, so when they are taking silage out, they create an overhang,” he said.

(Cited by WMUR TV, 2010)



Figure 7. People standing too close to a feedout face



Figure 8. Silage truck parked too close to the feedout face

It started out as a typical day for dairy nutritionist Doug DeGroff of Tulare, CA. He pulled up to a client's corn silage pile for a forage sample, bucket and pitchfork in hand. After filling the bucket, he turned to walk back to his pickup to mix and core a sample. "The sun basically went out – I could not see any light and the feed hit me on my head and covered me completely," says DeGroff. "I knew what was happening before I hit the ground. The entire face fell on me ... about 18 tons broke away." DeGroff, who had celebrated his 36th birthday with his wife and two toddlers two days before August 27 last summer, was caught in a silage avalanche. DeGroff offered these additional comments, "This particular pile did not look unsafe at all. It was only 11 to 12 feet tall at the time that I sampled it and was mechanically shaven. I personally have taken feed samples from piles where I should not have been. I knew they were not safe, but I took the risk. This pile looked safe from any angle you looked at it from. I feel very blessed to be here and that everything still works. Yes, it was a broken back, but it could have been so much more. I am not on pain medication, and I don't think there are going to be long-term issues."

(Cited by Holin, 2010)



Figure 9. Payloader operator removing silage from an over-filled bunker silo

On January 13, 2014, Jason E. Leadingham was working in a bunker silo when a massive amount (10 to 15 tons) of corn silage collapsed on him. Pirtle Farms LP of Roswell, NM who employed Jason as a trucker driver owned the silo. Jason's body was not recovered from the silage until about 2 and 1/2 hours later, and it was determined that he died of mechanical asphyxia. There was a sample bag near Jason's left hip. He was clutching silage in his hands and had silage in his mouth, which suggest that Jason struggled to survive in the final moments of his life.

(Cited by Bolsen and Bolsen, 2015)



Figure 11. An employee removing tire sidewalls that fell from the top of the bunker silo



Figure 10. Moments after Jason Leadingham's body was found in the corn silage, which had collapsed on him in a bunker silo



Figure 12. An over-filled bunker silo of corn silage with the feedout face being undercut by the loader operator

COMPLACENCY

Think safety first! Even the best employee can become frustrated with malfunctioning equipment or poor weather conditions, resulting in misjudging a situation, taking a hazardous shortcut or performing a risky action.

Mac Rickels, a dairy nutritionist in Comanche, TX almost lost his life the day he took silage samples from a bunker silo with a 32 foot high feedout face. Rickels said, "Even though I was standing 20 feet from the feedout face, 12 tons of silage collapsed on me. I did not see or hear anything. I had been in silage pits hundreds of times, and you just become kind of complacent because nothing ever happens. It just took that one time."

(Cited by Schoonmaker, 2000)

Never assume that a feedout face of a bunker or pile will not avalanche or collapse!

Personal communication from a nutritionist: "I had a near miss earlier this year. I was taking a core sample at one of our large dairy customers and had just moved away from the face when a large section just fell off . . . This was a very well packed silo and had immaculate face management."

(Cited by Holmes and Bolsen, 2009)



Figure 13. A feedout face in a bunker silo moments after an avalanche

CONCLUSIONS

It is best to take steps to eliminate or control hazards in advance than to rely upon yourself or others to make the correct decision or execute the perfect response when a hazard is encountered.

Only experienced people should be permitted to operate equipment associated with harvesting, filling, packing, sealing and feeding in a silage program.

The correct sizing of bunkers and piles can reduce the risk of an accident. Spreadsheet software is available to assist producers and their silage team to better design and manage bunker silos and drive-over piles (<http://www.uwex.edu/ces/crops/uwforage/storage.htm>).

Every farm, feedlot and dairy should have safety policies and procedures for their silage program, and they should schedule regular meetings with all their employees to discuss safety.

The MOST IMPORTANT GOAL in every silage program is to send all employees home to their families safe EVERYDAY!

If a silage program is NOT SAFE, then nothing else about it REALLY MATTERS at the end of the day.



Figure 14. Very well managed and safe drive-over pile of corn silage

RISKS FROM SILAGE GASES

Numerous gases, including carbon dioxide and nitric oxide, are produced during the first 2 to 3 weeks of the harvesting, filling and ensiling periods. Silage gases can accumulate in silos, feed rooms or livestock housing areas and can be fatal to humans and animals alike.

Nitric oxide changes to nitrogen dioxide when it contacts oxygen in the air. Nitrogen dioxide is toxic and can produce a sudden death. Even a brief exposure to NO₂ can be fatal.

Nitrogen dioxide is a reddish to yellowish-brown, heavier than air gas, which smells like laundry bleach. The highest levels of NO₂ are usually present during the first 24 to 72 hours after the forage is put into the silo, but dangerous levels can persist for up to 3 weeks.

When inhaled, NO₂ dissolves in the moisture on the internal lung surfaces to form nitric acid. This strong acid burns the pulmonary membrane tissue, effectively stopping the supply of oxygen to the body.

Depending on the NO₂ concentration, the presence of silo gas might be recognized by a burning sensation in the nose, throat, and chest. Exposure to high concentrations of NO₂ can cause death within minutes, and the victim would not likely have time to detect respiratory symptoms.

Exposure to low or moderate concentrations of NO₂ can cause permanent lung damage and pneumonia. Even small periodic doses of NO₂, such as those that result from working every day in a poorly-ventilated feed room located near the bottom of a silo chute, can lead to chronic respiratory problems, including shortness of breath, coughing and fluid in the lungs.

Accidental deaths and serious lung injuries that result from contact with NO₂ are usually associated with conventional, top-unloading silos. Leveling, sealing and unloader set-up operations in the confined headspace of these silos place entrants in peril during the 3-week danger period.

Carbon dioxide (CO₂) is odorless, colorless and tasteless, and it can be dangerous in a closed environment. When CO₂ reaches a certain concentration in the bloodstream, it triggers a nervous impulse that causes the victim to gasp for air. At higher concentrations, this reflex action is inhibited, and the victim is asphyxiated.

Carbon dioxide is particularly hazardous in sealed tower silos, where CO₂ replaces oxygen in the confined headspace. The contained atmosphere in the silo will be almost entirely CO₂, and human survival in such an environment is completely dependent on a safe external air supply.

In conventional, top-unloading silos, CO₂ can accumulate to dangerous concentrations by draining into low points on the silage surface.

Do not ignore carbon dioxide. It gives very little warning that a person is about to be overcome by a lack of oxygen.



FOLLOW THESE PRECAUTIONS TO REDUCE THE DANGERS ASSOCIATED WITH SILO GASES

- Properly adjust the distributor/spreader so the forage will be evenly distributed in the silo and will not require anyone entering the silo during or after filling.
- Beware of yellowish-brown fumes or bleach-like odors at the base of a silo; telltale signs of NO₂ gas.
- Post silo gas warning signs at the base of the silo chute and entrance to the feed room.
- Stay clear of the silo for at least 3 weeks after filling.
- Keep children and visitors away from the silo area during the 3-week danger period.
- Ventilate the feed room with open windows and fans during the danger period.
- Keep the doors between the silo feed room and livestock housing area closed tightly.
- If it is necessary to enter a silo at the completion of filling, do so as soon as the last load is off the truck or wagon. Do not wait until the next day and have the forage blower running while you are in the silo.
- If you must enter a silo within 3 weeks after filling, ventilate the silo by running the forage blower for 15 to 20 minutes with the door closest to the top of the silo open. You should wear an approved, self-contained breathing apparatus, and you should also be attached with a life-line to someone outside the silo.
- If you should experience even slight throat irritation or coughing around a silo, move into fresh air at once. **See your doctor immediately** if you suspect that you have been exposed to NO₂ gas.
- Remember: Silo gases do not give second chances!

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- Offers a higher level of expertise, leadership and industry commitment with long-term and profitable solutions to move our partners Forward.

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