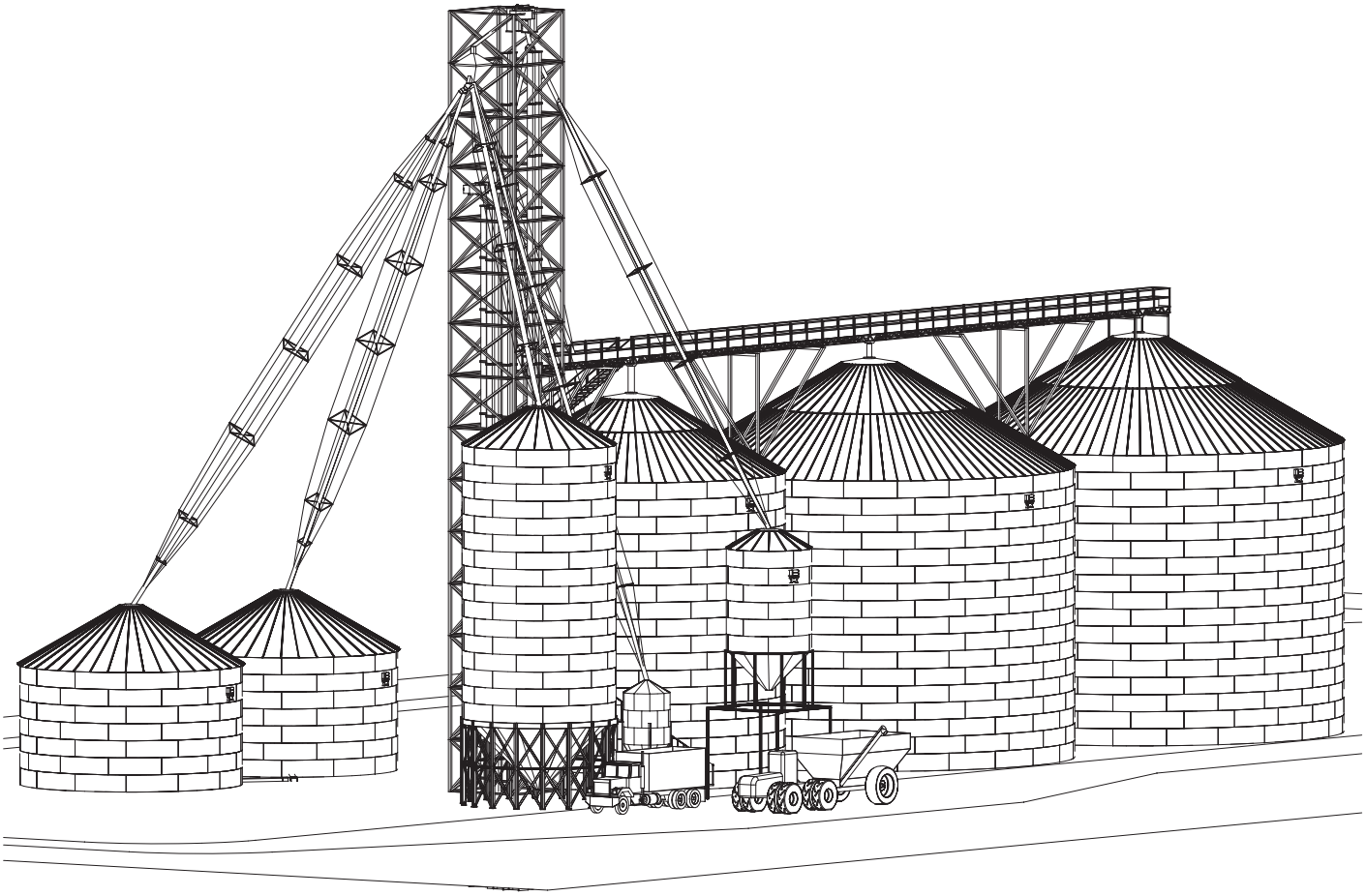
BEHLEN

GRAIN BIN OPERATION MANUAL



SYSTEM CERTIFICATION ISO 9001:2008 SGS

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1. Initial Guidelines

1.1. Initial Guidelines

1.1.1. Behlen grain bins are designed and manufactured to withstand the constant forces applied when filled with grain. When properly installed and operated, these storage structures will provide many years of service to our customers. Contractors who erect the structure must follow the guidelines listed below. Doing so will ensure the owner has a properly installed and operating grain bin.

1.1.2. **The Erection Manuals and assembly drawings must be thoroughly studied prior to construction**. Proper knowledge of the individual assembly procedures will aid in the safety and speed of construction time. Be certain to use the correct bolts for the appropriate hole locations as specified by the erection manual.

1.1.3. **Note:** The procedures and guidelines listed in this manual are recommended as part of specific measures and actions established per job. Due to the numerous situations at each site, Behlen Mfg. Co. is unable to provide a specific procedure checklist for each individual location. Owners/Operators are responsible for developing specific procedures or guidelines based on equipment, conditions, and situations at their individual locations and incorporate them into their technical data.

1.1.4. The contractor and owner should follow erection manuals and assembly drawings supplied with the products. **IMPORTANT: Keep galvanized sheets dry before erecting (see insert to right)**.

1.1.5. If any questions arise about the instructions and/or assembly drawings, before or during construction, contact Behlen engineering. They will assist you to clarify any questions about the instructions and/or drawings and resolve any problem(s) you may have during assembly.

1.1.6. **Failure to follow any installation, operation, or maintenance instructions established by Behlen Mfg. Co. or failure of the product resulting from exposure to corrosive materials, misuse, accident, normal wear and tear, unauthorized modification(s), improper maintenance, improper storage procedures prior to erection, or improper storage of grain will void the manufacturer's warranty and may result in structural damage, serious injury, or DEATH.**

Although every effort is made to ensure the erection manual and assembly drawings are written without errors, they may happen. Therefore, if any concerns arise regarding any instructions or assembly drawings, please contact Behlen Mfg. Co. immediately for clarification prior to proceeding with the construction process.

Please read entire the Operation and Erection Manuals paying close attention to the safety sections. Your failure to read these manuals is a misuse of the product, which could result in personal injury or property damage. It is recommended that all personnel associated with the bin thoroughly study these manuals as well.

NOTICE

KEEP GALVANIZED SHEETS DRY BEFORE ERECTING!

- **Coated steel panels are subject to corrosion and discoloration (white rust) if moisture becomes entrapped between sheets.**
- **Panels should be inspected for entrapped moisture upon arrival at the job site and properly protected and stored in order to prevent accumulation of moisture between panels.**
- **In addition to moisture due to rainfall, moisture can also form between panels due to condensation.**
- **When panels are not expected to be immediately installed, inside storage is recommended.**
- **It is also recommended that panels never be covered with plastic as ground moisture can collect under the plastic and lead to entrapped moisture.**
- **Behlen Mfg. Co. shall accept no responsibility for stains, corrosion, or other damage occurring to panels while stored on the job site.**
- **For details see the document: "Planning For The Receipt And Erection Of Your Behlen Grain Storage Bins." This document is sent with the order shipment.**

2. Safety

FOR YOUR SAFETY

2.1. Safety

2.1.1. Behlen Mfg. Co. strives to incorporate safety in its products, be it during handling, erection or operation. Safe working conditions, safe working methods and safe products should always be of prime concern to contractors, erectors and manufacturers.

2.1.2. Federal safety standards (O. S. H. A.) have been established by the Department of Labor. Employers are obligated to familiarize themselves with the requirements of the standards and put them into practice. Also follow state or local safety codes.

2.2. Recognizing Safety Decal Information

2.2.1. The safety-alert symbol above means **Attention! Be Alert!** Your personal safety is involved! This symbol draws your attention to important instructions concerning your personal safety. Read the message carefully to avoid personal injury or death.

2.3. Signal Words

These are words that indicate an estimate of likelihood of exposure to a hazard and the probable consequences of exposure to the hazard (reference: ANSI/ASABE AD11684:1995).

DANGER Indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be used sparingly and only for those situations presenting the most serious hazards.

WARNING Indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury. This signal word presents a lesser degree of risk of injury or death than those identified by the signal word DANGER.

CAUTION Indicates a potentially hazardous situation that, if not avoided, may result in minor or moderate injury. It may also be used to warn against unsafe practices associated with events that could lead to personal injury.

NOTICE Is the preferred signal word to address practices not related to personal injury. The safety alert symbol shall not be used with this signal word.

2.4. Decals

2.4.1. Several decals are attached to the equipment at various places to call your attention to messages concerning your personal safety. Read and heed the message and be alert to the possibility of personal injury or fatality. Decals are placed according to Figure 1.

IMPORTANT: TO PREVENT SERIOUS INJURY OR DEATH TO YOU OR SOMEONE ELSE, IT IS ESSENTIAL THAT THESE SAFETY DECALS ARE MOUNTED ON YOUR BIN.

2.4.2. It is your responsibility as an owner, operator or supervisor to know what hazards exist and to make these known to all other personnel working in the area, so that they too may take any necessary safety precautions that may be required.

2.4.3. Decals are attached to equipment at various locations with specific messages. Pay attention to messages and always be alert to the possibility of personal injury or death.

2.4.4. If the decal(s) become damaged or detached, contact your Behlen representative or Behlen Mfg. Co. for replacement decals.

WARNING

ALL OF THE FOLLOWING INFORMATION IS WARNING INFORMATION!

2.5. Operating Safety

- Before you perform any service on the equipment, or enter the bin, make certain that the main power disconnect switch is locked in the “off’ position.
- Guards and Shields are provided for your protection. Keep them in place and secure while machine is in operation.
- Replace safety shields that may have been damaged or removed for servicing purposes and fasten securely before operating machinery.
- Keep all persons away from any hazard areas.
- Keep hands, feet and clothing away from moving parts. Loose clothing can become entangled in rotating parts and cause serious injury.

FOR YOUR SAFETY

- Be aware of the danger that is present when loading or unloading a grain bin. Grain that has bridged or tunneled may suddenly break loose and trap a person who may be inside the bin. Death by suffocation can result. Avoid entering the bin until the grain is removed.
- Ladders and walking and working surfaces should have safety cages and handrails for safe use. Use a lifeline and harness when the danger of falling exists.
- Proper operational procedures must be followed to ensure the safety and well being of all persons working near or on grain bins when inspecting grain, conducting maintenance, and spraying insecticides.
- Hazards associated with grain bins include engulfment and burial, falls from heights, dust and mold inhalation, pesticide exposure, electrocution, and injuries from augers. Take precautionary steps to avoid these hazards.
- Learn how to use controls and operate equipment correctly. Do not let anyone operate equipment without thorough training of basic operating and safety procedures.
- Periodically check all mechanical and electrical components to keep them in good working condition. Make no unauthorized modifications to the equipment. Doing so may endanger function and safety of the equipment.
- Be aware of weather-related safety hazards. Icicles and snow falling from bin eaves are dangerous and can cause serious injury or even death. Ice or moisture on ladders can cause slippery conditions that may result in life-threatening falls.
- For added security and safety, attach a padlock to sidewall door latch.

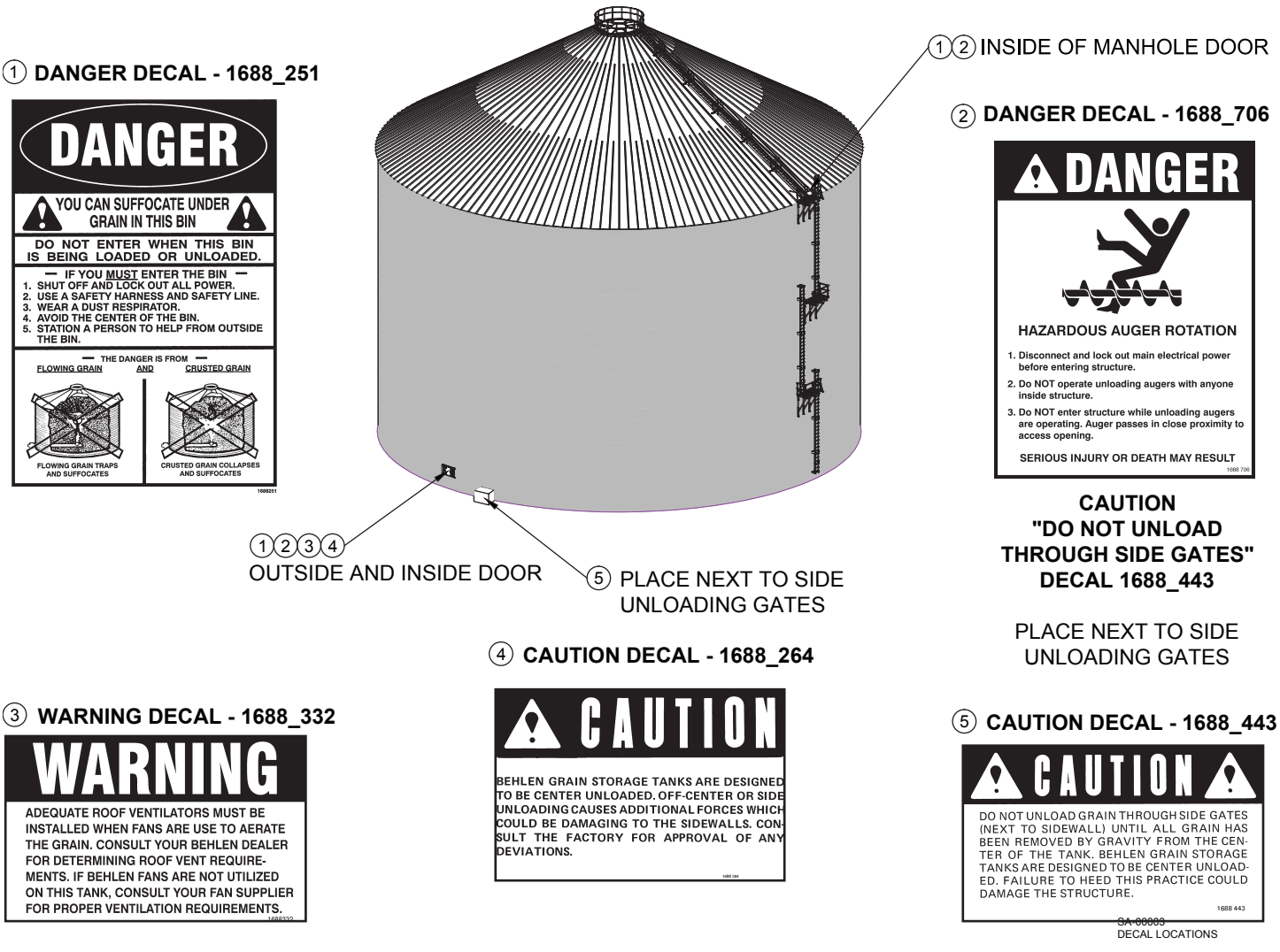


Figure 1. Safety decal placement.

2.6. Flowing & Crusted Grain

2.6.1. People can become caught or trapped by grain in several ways: entrapment by flowing grain, collapse of bridged grain, and collapse of a vertical wall of grain. To better understand why grain flow is so dangerous, you must understand how grain flows when it is unloaded. Grain bins are first emptied through center sumps (bins erected with a side-draw are the only exception). When a center sump is opened and the auger is started, grain flows from the top surface down a center core to the center sump. This is called funnel flow and is illustrated in Figure 2 below.

2.6.2. Grain across the bottom and around the sides of the bin does not move. The speed at which grain is removed makes the funnel flow very dangerous. A worker in the bin will be carried to the center, quickly drawn under, and suffocated. An 8" auger can transfer 3,000 cubic feet of grain per hour (50 cubic feet per minute). A person about 6' tall displaces about 7.5 cubic feet, assuming an average body diameter of 15 inches. This means the entire body could be submerged in funnel in about 8 seconds. Even more importantly, you could be up to your knees and totally helpless to free yourself in less than 4 seconds.

2.6.3. A grain surface may appear solid but not be. A small opening in the unload gate gives the entire surface the quality of quicksand. When a single kernel is removed from the bottom of the bin, kernels directly above it rush to fill the void. Flowing grain is like a fluid; objects on the surface sink and heavy objects sink faster than lighter ones.

2.6.4. Flowing grain is like water in that it will exert pressure over the entire area of any object that is submerged in it. However, the amount of force required to pull someone up through grain is much greater than in water because grain exerts no buoyant force and has much greater internal friction.

2.6.5. Even if grain has stopped flowing, submerged objects or people are difficult to extract. Victims with tremendous upper body strength cannot pull themselves out if they are buried to the chest. The force required to remove someone buried below the surface of grain can easily exceed 2,000 pounds, which is about the same as lifting a small car.

2.6.6. If you do become trapped in a bin of flowing grain with nothing to hold onto, but you are still able to walk, stay near the outside wall. Keep walking until the bin is empty or grain flow stops. Also, if you are covered in flowing grain, cup your hands over your mouth and take short breaths. This may keep you alive until help arrives. Additional help should call for an emergency rescue team or fire department immediately. Ventilate bin with an aeration system but DO NOT activate the heat source. Wait for emergency crews to arrive before attempting the rescue. Offer assistance to rescuers, and follow only the directions given to you by the incident commander.

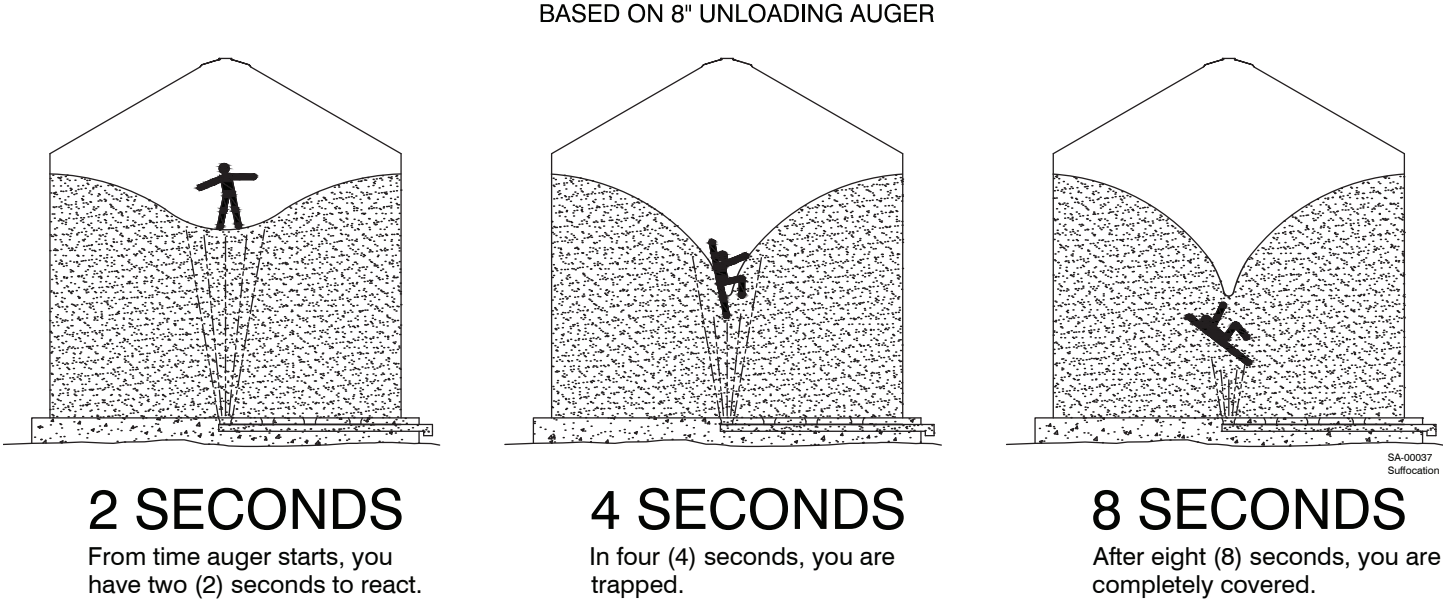


Figure 2. Time to take to completely be entrapped by flowing grain.

2.7. Bridged & Collapsed Grain

2.7.1. Spoiled grain tends to clump together and grain that is stored in cold temperatures can appear to have a solid surface while, in reality, it may collapse if walked upon. Be aware of a potential engulfment hazard when walking on surface crust. Never enter a bin unless you know the nature of previous grain removal, especially if any crusting is evident and proper safety precautions have been taken. **After grain has been removed, look for a funnel shape at surface of grain mass. If grain appears to be undisturbed, then it has bridged and created a cavity.**

2.7.2. Bridging grain may create air spaces in a partially unloaded bin, see Figure 3. As grain is removed from a bin, a cavity develops under the crusted surface. This situation presents several dangers. First, the person may break through the surface and be trapped instantly in the flowing grain. Another danger is that a large void may be created under the bridge by previous unloading so that a person who breaks through the crust may be buried under grain and suffocate, even without an auger running. The third hazard is that, if grain is wet enough to mold and bridge across bin, there may be little oxygen present in the cavity due to microbial gases. A person falling into a cavity will be forced to breathe toxic gases, even though his head is above surrounding grain. From outside the bin, use a pole or other object to break bridge, causing it to collapse.

2.7.3. Grain can also form in a large mass against wall, see Figure 4, when it has been stored improperly or in poor condition. The mass of grain can cause engulfment or crushing hazards to workers who attempt to break it loose with shovels or other objects.

2.7.4. This risk increases as the capacity of bins increase. A person lying prone and covered by one (1) foot of grain will be subjected to a force of more than 300 lbs. Be alert while working with grain that has gone out of condition. Entering a bin when there may be molds, blocked flow, cavities, crusting, and possible cave-ins can cost you your life. When you are breaking up large masses of vertically crusted grain, do so with a long wooden pole from manhole above grain.

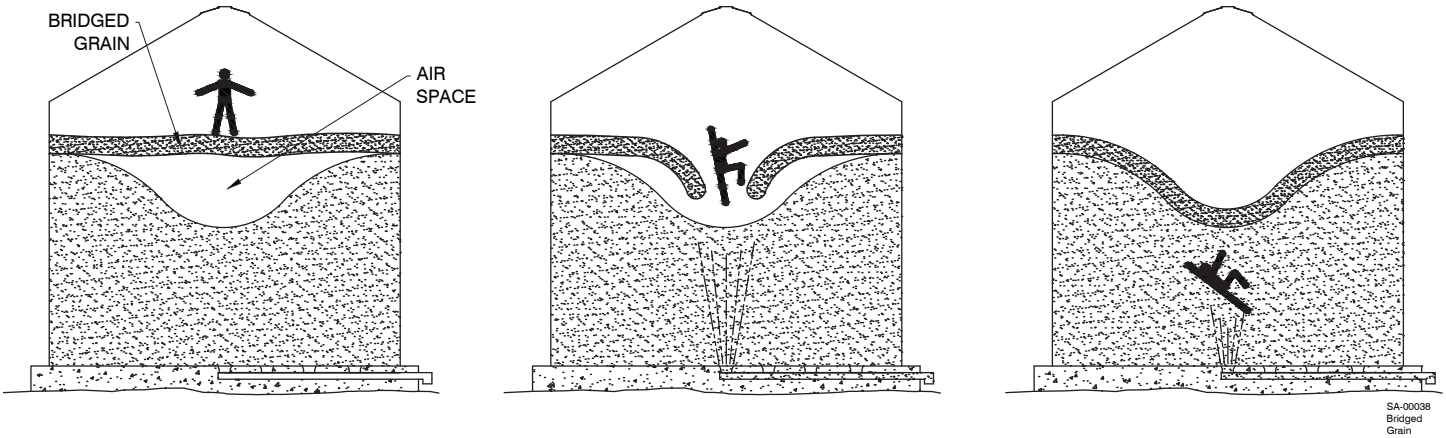


Figure 3. Dangers of bridged grain.

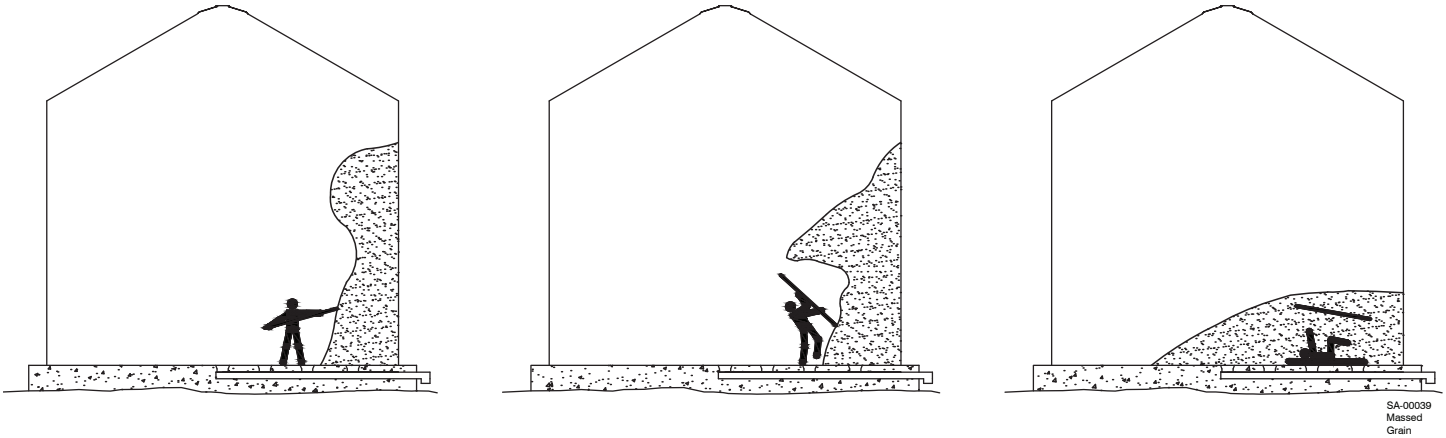


Figure 4. Dangers of grain massed on a sidewall.

2.8. Falls & Obstructions

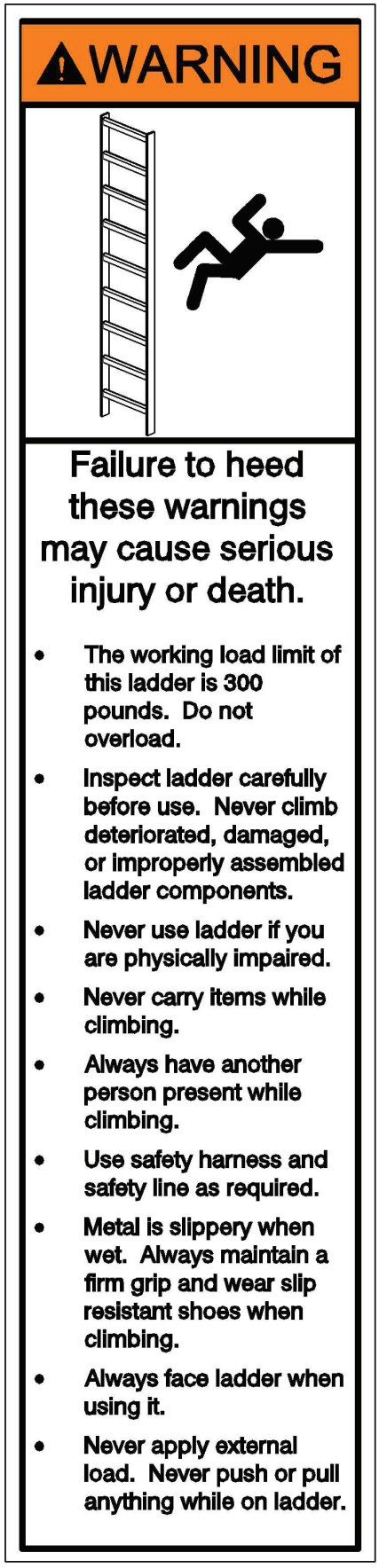
2.8.1. Falls from grain bins at any height can cause injury. Ladders on bins can become very slippery or icy in inclement weather. Maintain a secure hand-hold and foot-hold when climbing on the bin. Metal is slippery when wet. Never carry items while climbing on bins. Also, be certain no obstacles are in front of ladder.

2.8.2. Slippery metal, broken or loose ladder rungs and loose hand-holds can be very dangerous. Repair loose ladder rungs and hand-holds as soon as they are discovered. Follow maintenance guidelines listed at the back of the operation manual to prevent serious injury.

2.8.3. Make sure there are no obstructions near ladder rungs which could cause a fall.

2.8.4. When ladders are used to ascend heights exceeding 20', the American Society of Agricultural and Biological Engineers (ASABE) standards state that landing platforms shall be provided at each 30' of height. Center of the outside ladder must be at least 7" from sidewall.

2.8.5. **NOTE: Failure to purchase ladder and safety cages and use of fall restraints and arrest systems correctly may cause serious injury or even death. Contact your dealer if proper ladder and accessories are not installed.**



SA-00036
Ladder Warning

2.9. Fall Restraints & Arrest Systems

2.9.1. When working on a bin at a height where fall hazards exist, always use a fall restraint or fall arrest system. Inspect fall restraint and arrest components before each use for wear, damage and other deterioration. Remove defective components from service according to manufacturer instructions. Failure to heed this warning may cause serious injury or death.

2.9.2. A **fall restraint system** consists of a body belt or harness, lanyard and anchor. The system is arranged so the individual is prevented from falling. Fall restraint systems should be used in accordance with manufacturer's recommendations and instructions.

2.9.3. A **fall arrest system** consists of a harness, lanyard and anchor. The system exposes a worker to a fall, but stops the fall within specified parameters. Fall arrest systems should be used in accordance with manufacturer's recommendations and instructions.

2.9.4. Lifelines and safety harnesses are used with both systems. A lifeline is a component consisting of a flexible line (rope or cable) for connection to an anchorage at one end to hang vertically (vertical lifeline), or for connection to anchorages at both ends to stretch horizontally (horizontal lifeline). Lifelines also serve as a means for connecting other components of a fall protection system. A safety harness has straps that wrap around an individual in a manner that will distribute the fall arrest forces over thighs, pelvis, waist, chest, and shoulders with a means of attaching it to other components of a fall protection system. Follow manufacturer's instructions when using a lifeline and safety harness.

2.9.5. Individuals who enter a grain storage structure from a level at or above stored grain should be equipped with a lifeline and harness. When entering any bin or storage unit, have multiple people outside and one inside. A single person cannot go for help and give first aid simultaneously.

2.9.6. Connections outside the bin on the roof should be made to the peak ring. Lifelines should not let an individual extend past the eaves of the roof. If work needs to be done on portions of the sidewall, proper equipment such as lifts or cranes should be used. When working inside the bin, appropriate connections should be made to the rafters, peak ring or sidewall.

2.10. Sharp Edges & Obstacles

2.10.1. When working on or near a bin, remember that metal edges are sharp. Care must be taken when handling or working near various pieces of the grain bin. To avoid injuries, wear protective clothing and handle equipment and parts with care. An excellent safety practice is to keep the bin sites clear of scrap iron and other foreign materials that may get covered up by snow or tall grass. Any item or debris left near bin site will interfere with safe, unobstructed movement around bin.

2.10.2. Be aware of trucks, tractors, wagons, augers, hoppers and pits, etc. Never allow anyone to ride on trucks equipped with grain beds or gravity dump wagons. Keep children off of grain vehicles and out of bins while loading and unloading. Always know where all employees or family members are (especially children) at all times when grain is being loaded, unloaded, moved, or otherwise handled.

2.11. Entering a Grain Bin

2.11.1. Individuals should never enter a grain bin while the bin is being loaded or unloaded. This involves a risk of being crushed or suffocated by flowing grain. Entering a bin that has bridged grain is very dangerous. Working in grain bins without following proper operational procedures increases an individual's chance of being suffocated. If stored grain is peaked close to the roof, be extremely cautious. Crawling between the roof and the peaked grain can cause grain to cave and block the exit.

2.11.2. When entering a bin, owners/operators are responsible for following site-specific confined space entry procedures. OSHA's confined space entry procedures (29CFR 1910.146) can be obtained at www.osha.gov.

2.12. Lock-Out/Tag-Out

2.12.1. Lock Out/Tag Out refers to specific practices and procedures to safeguard unexpected energization or startup of machinery and equipment, or release of hazardous energy during service or maintenance activities. This requires, in part, that an authorized individual isolate machinery or equipment from its energy source(s) before performing service or maintenance. It also requires authorized individual(s) to either lock or tag energy-isolating device(s) to prevent release of hazardous energy, and take steps to verify energy has been isolated effectively.

2.12.2. Grain storage structures and handling equipment may create hazardous work areas. Individuals should make sure they take proper steps to prevent injuries, illness, or even death. Be certain proper lockout/tag-out procedures are followed before performing any service on equipment or entering bin.

2.12.3. **Lock-Out** refers to a device that uses a lock, either key or combination type, to hold an energy-isolating device in a safe position and prevent energizing of a machine or equipment. This device ensures that equipment being controlled cannot be operated until the lockout device is removed. Tags must be used with all locking devices. Tags should be affixed in such a manner that clearly identifies the individual servicing the equipment.

2.12.4. **Tag-Out** refers to placement of a tag on a device that is not capable of being locked out, to indicate equipment may not be operated until tag device is removed. These tags are singularly identified with the individual applying the device and servicing the equipment. These tags **do not** provide physical restraint on those devices that require a restraint.

2.12.5. Owners/Operators are responsible for developing site-specific Lock Out/Tag Out procedures based on equipment, conditions, and situations at their individual locations. OSHA's Lock Out/Tag Out procedures (29CFR 1910.147) can be obtained at www.osha.gov.

2.13. Ventilation

2.13.1. When entering an inadequately ventilated area, individuals may be at risk of being overcome by respiratory hazards (gases, fumes and dust) that can cause permanent lung damage or even death. Working in grain bins without proper respiratory protection increases a person's chance of developing a respiratory disease.

2.13.2. Owners/Operators are responsible for developing site-specific personal protective equipment standards. OSHA's personal protective equipment standards (29CFR 1910.134) can be obtained at www.osha.gov.

2.14. Moving Parts

2.14.1. When the bin is nearly empty, the sweep (floor) augers travel at faster speeds around the bin. The danger of the auger lies with how the auger works to move the grain. If caught in the rotating shaft, a body part can be pulled along with the grain, cutting and tearing the flesh. Also, remember that an exposed auger in the sumps can cause serious injury if stepped or fallen into. All shields should be in place to prevent body parts from getting caught. **NEVER ENTER A BIN WHEN IT IS BEING LOADED OR UNLOADED!**

2.14.2. In order to help prevent any tragedy, **SAFETY SHOULD BE THE TOP PRIORITY**. Preparation is the first and most important step. Failure to follow the precautions listed below may cause serious injury or even death.

- Keep hands, feet and clothing away from moving parts. Loose clothing can become entangled in rotating parts and cause serious injury or death.
- Guards and shields are provided for your protection. Make sure they are all secure and in place while the machine is in operation.
- Replace safety shields that may have been damaged or removed for servicing purposes and fasten securely.
- Be sure to wear tight-fitting clothing when working near a grain auger. Loose, floppy clothing, long shoestrings and drawstrings on hooded jackets can easily become entangled in rotating parts. Entangled clothing will pull the body into moving machinery and severe injury or death will result.
- Limit the number of people around augers when in use. Only those who are essential to job should be there.
- Watch children closely. Keep them away from vehicles, flowing grain, and moving parts. Small

hands and feet can penetrate even properly shielded augers, belts, and PTO's. Teach them which areas are safe and which are not.

- Be certain all machinery is in good working condition.

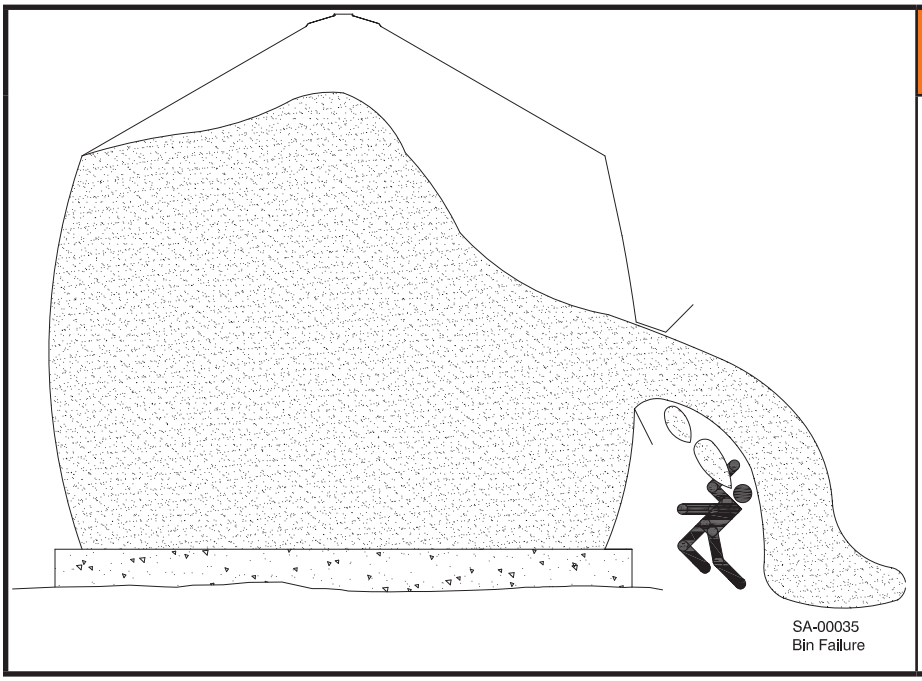
2.15. Top Causes of Bin Failure

- Off-center (eccentric) unloading and/or loading
- Non free-flowing grain (spoiled, frozen, crusted, etc.)
- Door panels not tightly secured against inner door frame
- Augers, spouts, or conveyors improperly attached to roof
- Sidedraw improperly installed and/or operated
- Rusted wall sheets
- Simultaneous loading and unloading
- Settling of foundation (uneven pad)
- Improper storage and aeration
- Storing wet and dry grain in the same bin without stirring
- Neglect of bin maintenance
- Modifications made during installation or assembly
- Incorrectly installed sidewall sheets and/or stiffeners
- Blocked roof vents cause excessive pressures on roof (overfilling, frosted vents, etc.)
- Improper temperature cable support and/or placement

WARNING

DO NOT CUT HOLES INTO THE BIN SIDEWALL!

THIS WILL CAUSE AN UNEVEN LOAD DISTRIBUTION AND MAY CAUSE BIN FAILURE, WHICH CAN RESULT IN PERSONAL INJURY OR DEATH!



WARNING

Damage from one of the issues listed above may cause sudden structural failure and collapse, which may result in personal injury or even death. Frequently monitor and inspect bin and foundation for any deflections, cracks, or deviations that may occur. Follow operation and maintenance instructions described in this bin manual.

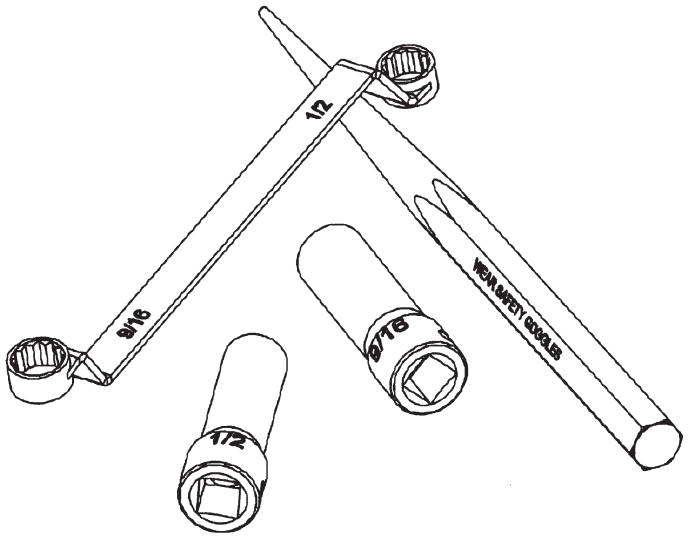
2.16. Construction Safety

2.16.1. To avoid serious injury or even death, it is important that the owner/operator becomes knowledgeable of operational procedures of a grain bin. Carefully review detailed information presented in this grain bin operation manual. Following proper operational procedures will not only ensure safety of owner/operator, but will give many years of extended service from the product.

2.16.2. On grain bin construction sites, carelessness and/or operator error may result in serious injury or even death. Hazard control and accident prevention are dependent upon awareness, cautiousness, and proper training of personnel involved in construction of the product. Be certain all crew members are properly trained and thoroughly familiar with all aspects of grain bin construction.

2.16.3. Listed below are items construction crew members should be knowledgeable of to minimize risk of injury to personnel and damage to equipment. Note: the following items are examples taken from a broad list of OSHA's Safety and Health Regulations for Construction. Generally, these are common requirements/items necessary on grain bin construction sites.

- **Personal Protective Equipment**
  - Head Protection
  - Hearing Protection
  - Eye and Face Protection
  - Steel Toed Boots/Shoes
  - Gloves
  - Breathing Protection
- **Concrete Construction**
- **Material Handling & Storage**



- **Tools – Hand and Power**
- **Welding and Cutting**
- **Electrical**
- **Ladders**
- **Scaffolds and Working Platforms**
- **Fall Protection**
- **Steel Erection**
  - Center Pole (Roof) Jack*
  - Bin Jacks*
- **Powered Equipment**
  - Trenchers
  - Forklifts
  - Skidsteers
  - Telehandlers
  - Boom Lifts
- **Cranes and Hoists**
- **Signs and Signals for Use of Powered Equipment**

2.16.4. ***NOTE:** Be certain to read and fully understand correct operating procedures for bin jacking equipment. This equipment is provided with the understanding that the purchaser/operator are thoroughly familiar with correct applications and proper usage techniques. Jack manufacturers will assume no responsibility for damage to equipment or any injury resulting from operation of their equipment.

2.16.5. When constructing a grain bin, erectors/contractors are responsible for developing site-specific construction guidelines and procedures based on equipment, conditions and situations at their individual location. OSHA's Safety and Health Regulations for Construction (29CFR1926) can be obtained at www.osha.gov.

WARNING

Please call your state's "Call Before You Dig" one-call notification system to have local utilities locate their underground facilities before any excavation or digging. To not do so could result in injury or death and can be a criminal offense.

3. Planning Preparations

3.1. Site Selection

3.1.1. When selecting a grain storage and handling site, many factors need to be considered. The site should allow convenient access for loading and unloading as well as workability if the site is to become a grain system center. Positioning and placement of handling equipment, fans, heaters, ladders, stairways, etc. must be predetermined. Also, be aware of any underground electrical cables or gas pipes before digging.

3.1.2. Figure 6 below shows an example of a bin site expansion project. Future grain bin locations are also shown. Although not all storage systems look like the one below, expansion projects should start with a top layout view of existing storage bins and components. When considering future expansion or updating a grain drying, storage, and handling system, think long-term.

3.1.3. Future site expansion should be factored into the site selection process and careful consideration must be paid to the electrical and gas supplies, as well as keeping safe distances from power supply sources. Be certain that suitable soils surround the area in all directions for possible expansions. Also, the site's environmental conditions should be tested before a site is considered as a suitable grain storage location.

3.1.4. Crop yields, acreages, and equipment sizes will continue their upward trend, so allow plenty of room for vehicles and for expansion. It may be necessary to plan for high capacity grain movement. Include large dump pits, holding bins, and conveyers.

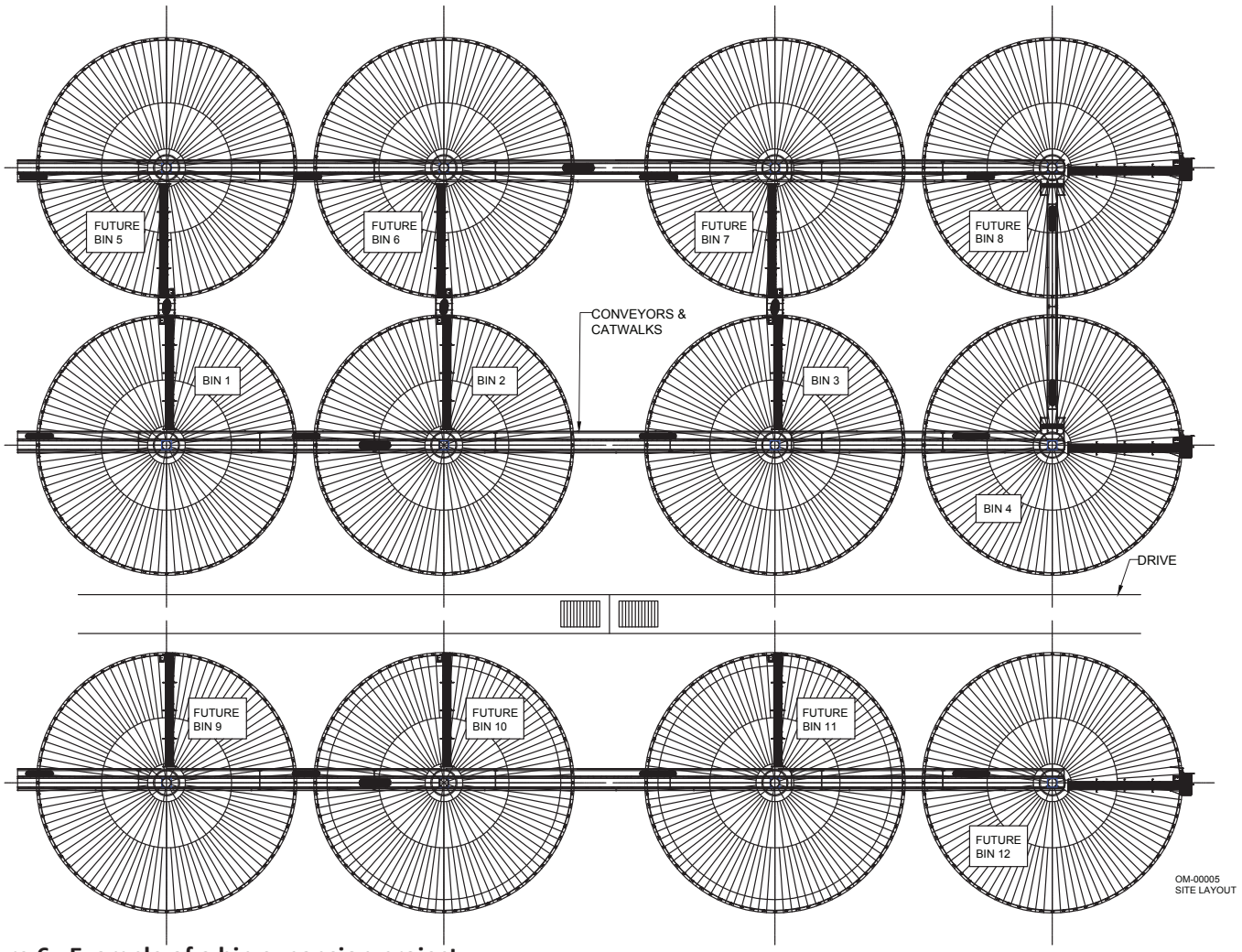


Figure 6. Example of a bin expansion project.

3.2. Selecting Builders & Contractors

3.2.1. Initial cost is important, but selecting reliable builders and suppliers that promptly service equipment when required is even more important. Purchases are often based on initial cost only. However, more expensive equipment that performs well is better than less expensive equipment that breaks down frequently. Check the performance of builders and equipment suppliers with other owners.

3.2.2. To select a consulting engineer, consider technical qualifications, reputations with previous clients, experience on similar projects, availability to the project, and registration. All states certify and license engineers of proven competence. Practicing consulting engineers must be registered professional engineers in their state of residence and be qualified to obtain registration in other states where their services are required.

3.2.3. Problems often result in poor communication. Verbal communication is easy to misinterpret. Put agreements in writing and have it signed by both parties. Important points to be agreed upon in writing are: equipment and when it will be installed; construction and when the site will be up and running; insurances; warranties; and payment procedures.

3.3. Foundation

3.3.1. Damage to a bin can result from factors including poor soil, the wrong type of concrete, and construction method used. The strength and stability of a footing or foundation depends on factors such as (1) climate, (2) subsidence, (3) elastic and/or plastic deformations, (4) shear deformation, and (5) soil consolidation. Any number of these factors may be present on a given foundation project, and each is relatively independent of the other; that is to say, each must be considered and dealt with separately. To be safe from one stand-point does not necessarily ensure one's being safe from any of the others.

3.3.2. Behlen Mfg. Co. recommends the following: Soil-boring tests shall be performed by a competent, independent geotechnical engineering firm.

3.3.3. The foundation shall be designed by an independent professional structural engineer.

3.3.4. Finally, the concrete foundation construction shall be constructed by a knowledgeable concrete contractor.

3.3.5. Wall loads and floor pressure for Behlen grain bins are available from Behlen Mfg. Co. to the structural engineer upon request.

3.3.6. Check for any local or regional building codes and regulations to ensure compliance.

3.3.7. It is customary for the bin owner to provide a level, clean, compacted site before concrete work begins.

3.3.8. Fill earth shall contain no rocks, vegetation or foreign material. Fill shall be added in layers not to exceed 4 in. (100 mm) and thoroughly compacted. Continue until finished grade is reached.

3.3.9. Proper drainage of the immediate area is necessary.

3.3.10. A "floating slab" design is more susceptible to settlement. Therefore, local conditions may not lend themselves to use of a floating slab.

3.3.11. If an unloading tube or aeration system is to be used with the grain bin, necessary provisions shall be made. The unloading tube must not interfere with the anchor bolts or aeration tunnel.

3.3.12. The concrete finished surface shall have the following design parameters.

- Maximum deviation over any 10 ft. (30.5 m) span of foundation surface: ¼ in. (6 mm) MAX.
- The maximum overall deviation of the grain bin foundation (concrete), before grain bin erection (see figure 26):
  - For 60 ft. (18.3 m) diameter and smaller: ½ in. (13 mm) MAX.
  - For larger than 60 ft. (18.3 m) diameter: ¾ in. (19 mm) MAX.
- Maximum uneven settlement (deviation) after filling the grain bin (includes overall concrete deviation before bin erection) (see figure 26):
  - For 60 ft. (18.3 m) diameter and smaller: 1 ½ in. (38 mm) MAX.
  - For larger than 60 ft. (18.3 m) diameter: 2 in. (51 mm) MAX.
- The concrete floor shall have a 1 to 24 slope from the bin wall to the outside edge of the footing. This allows water to drain away from the bin wall.
- If the concrete floor should "slope in" from the bin walls, outside water may seep into the bin and cause grain spoilage. Extra care in the final finish cannot be over-stressed.

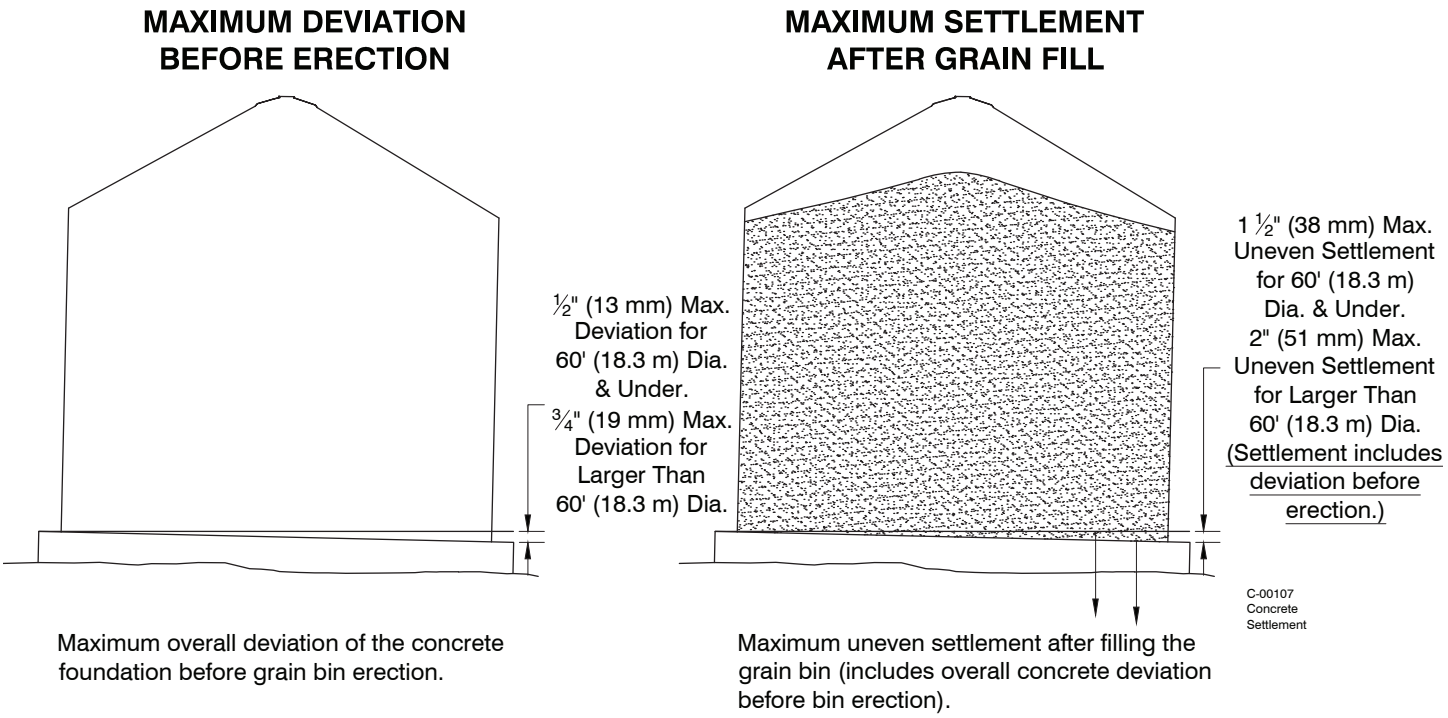


Figure 7. Concrete foundation maximum deviation and maximum settlement.

NOTICE

IMPORTANT! Once the grain bin is up, check regularly to ensure anchor bolts are properly installed so the grain bin will be able to withstand high winds.

3.4. Electrical Wire Clearance

3.4.1. When selecting a site for grain storage and handling or for a future expansion project, careful consideration must be paid to electrical and gas supplies, as well as maintaining safe distances from power supply sources. The American National Standards Institute (ANSI) provides safety recommendations for grain bins in (ANSI) C2-2007 "National Electrical Safety Code, Rule 234. Figures 8 and 9 show recommended distances for grain bins and grain handling equipment around power lines.

3.4.2. When constructing a new grain bin or grain storage system, please contact your local electric utility. It will provide assistance in planning a safe environment for everyone working around grain bins. States require specific clearances for electric lines around grain bins. Be certain your local electric utility regulations are in compliance with the state regulations. To prevent overhead safety issues, bury electrical lines.

3.4.3. Figure 8 shows specific clearances required when portable equipment is used. Grain bins filled by permanently installed augers, conveyors, or elevators (see Figure 9 as a guide) have specified clearances that require contacting local electric utilities for information.

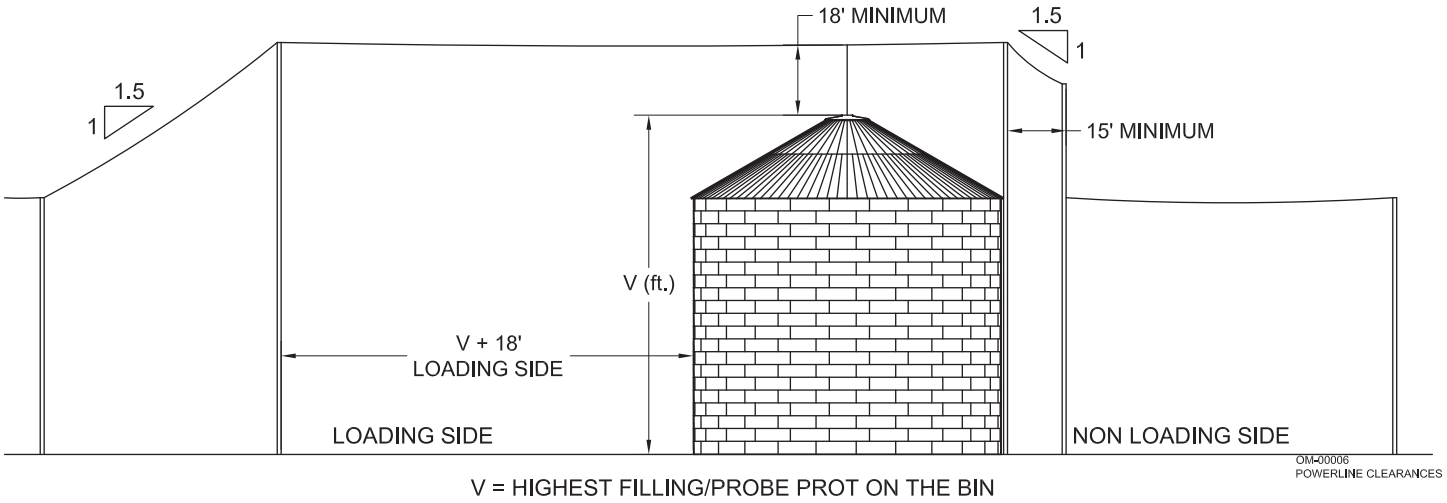


Figure 8. Electrical wire clearance for grain bins filled by portable augers, conveyors, or elevators. Source: American National Electric Safety Code," Rule 234.

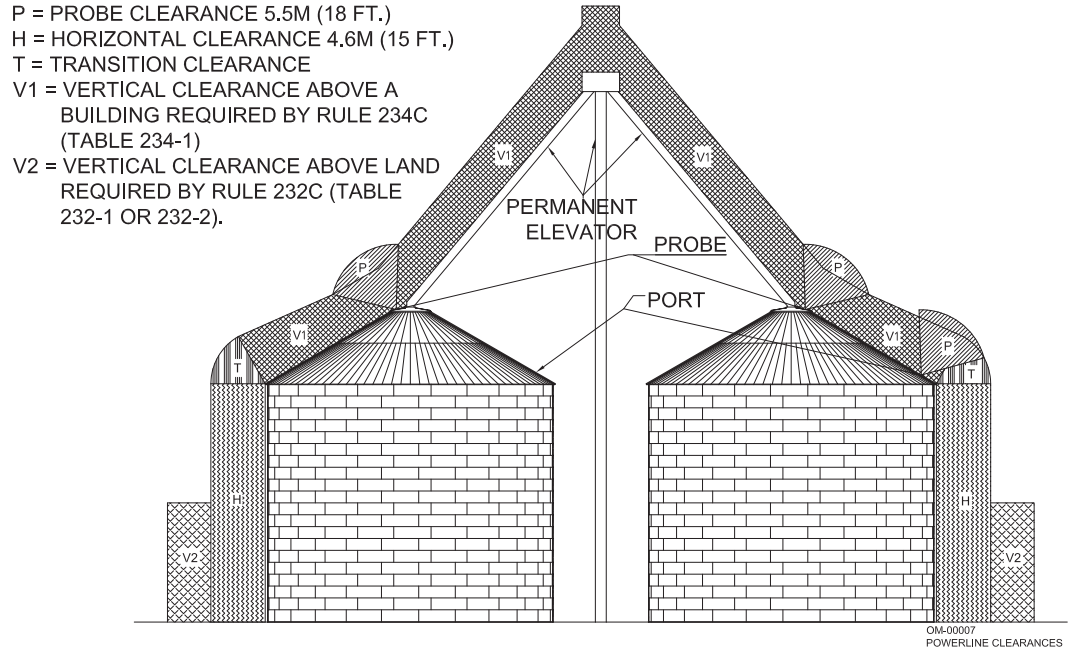


Figure 9. Electrical wire clearance for grain bins filled by permanently installed augers, conveyors, or elevators. Source: American National Standards Institute (ANSI) C2-2007 "National Electric Safety Code," Rule 234.

NOTICE

An electric utility may refuse to provide service to any grain bin built near an existing electric line that does not provide the clearance required by the American National Standards Institute (ANSI) and the National Electrical Safety Code.

3.5. Component Location

3.5.1. It is important that all components of the grain bin be properly located to maximize efficiency and effectiveness of equipment. Most factors should be considered before the foundation is poured. Double check the desired location of the side entry door, roof door, sidewall and roof ladders, fan and/or heater(s), unloading tube, eave platform(s), walkway(s), and venting equipment. If there is a peak lid, it should slide away from the roof ladder (if there is one). Figure 10, is a suggested typical layout.

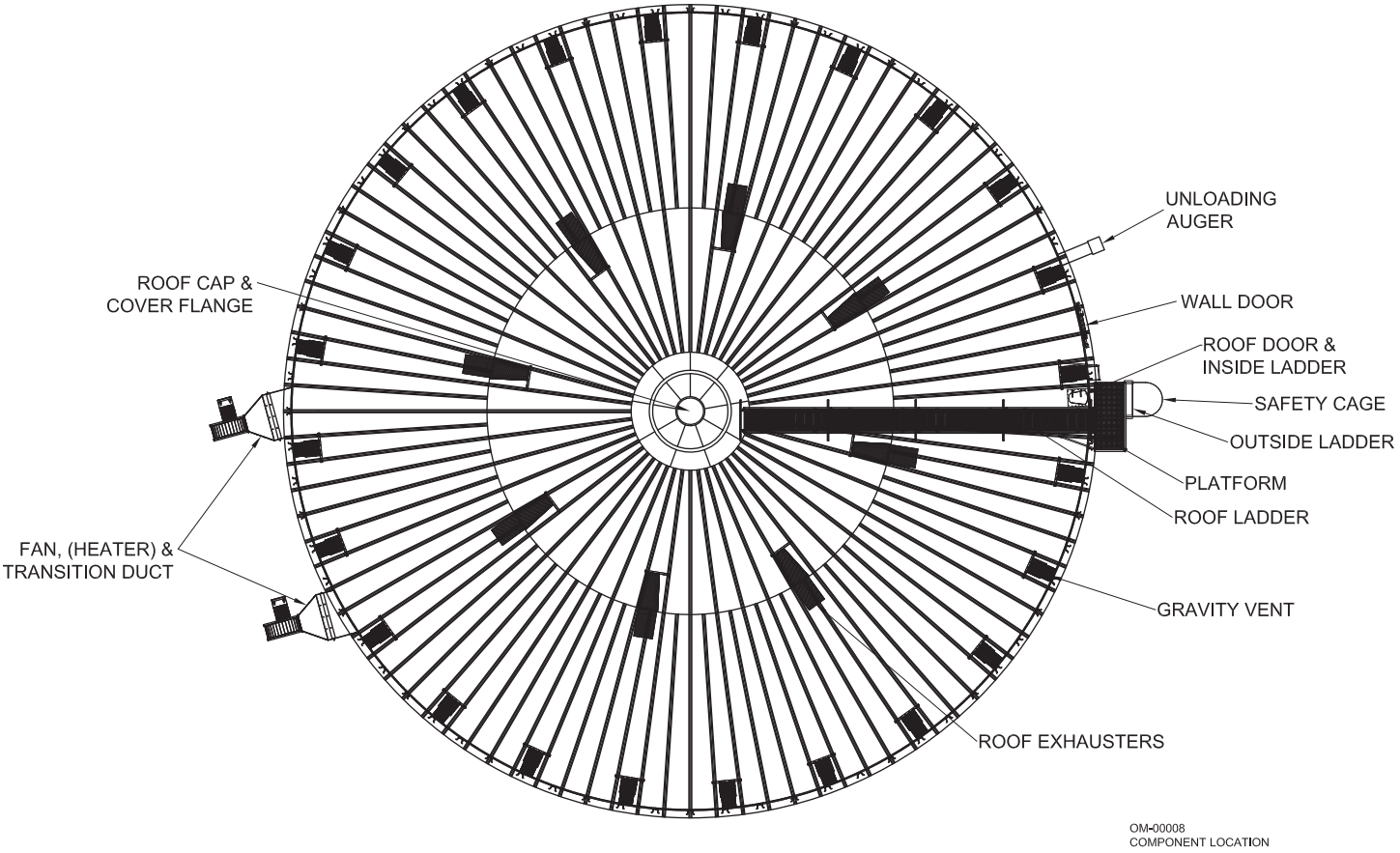
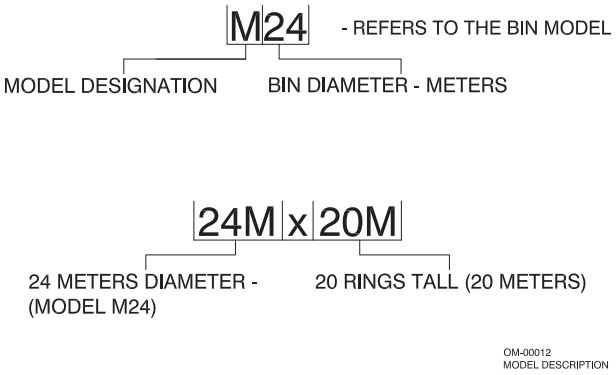


Figure 10. Typical component location. Note: Hopper bottom bins may not include side entry doors, fan(s), and/or heater(s), unloading tubes, and venting equipment.

4. Bin Operations & Management

4.1. Bin Description

4.1.1. Behlen grain bins are designed to meet different applications. Engineers considered customer needs, efficiencies in design, production technology, ease of construction and longevity. Listed below are the different grain bin series provided by Behlen Mfg. Co. Check to be certain what type of bin you ordered and received. The bin model number is described in the following example.



- Unstiffened Series: Bin models M5 through M15 (16'5" through 49'3" diameter), 4 through 9 rings tall (13'3" through 29'8" eave height).
- Stiffened Series: Bin models M9 through M15 (29'6" through 49'3" diameter), 9 through 24 rings tall (29'8" through 78'11" eave height).
- Commercial Series: Bin models M15 through M32 (49'3" through 105'0" diameter), 13 through 30 rings tall (42'10" through 98'6" eave height), depending upon bin model.
- Big Bin™Series: Bin models M40B and M48B (131'3" and 157'6" diameter respectively), maximum 26 and 24 rings tall (85'6" and 78'11" eave height respectively), depending upon bin model. Maximum capacity for this series is 1.5 million bushels.
- Commercial Hopper Tanks: Models M5 through M11 (16'5" through 36'1" diameter), 4 through 17 rings tall (maximum eave height varies with diameter).

4.2. Bin Usage

4.2.1. Behlen Mfg. Co. grain bins are used for grain storage, handling, and conditioning systems. These facilities process a wide variety of products including: corn, oil seeds, rice, wheat, and coffee beans. Behlen grain bins are shipped worldwide and all of these products are designed to meet specific, individual requirements.

WARNING

OBSERVE ALL SAFETY PRECAUTIONS IN THIS MANUAL!

WARNING

Do not enter this bin while it is being loaded or unloaded!

4.3. Initial Fill Of The Bin

Inspection Checklist Before First Operational Use

- Bin has been properly anchored to foundation.
- All bolts are in place and properly tightened.
- All guards and shields are in place. Safety decals are legible and in correct locations.
- Ladders, handrails, platforms, stair and steps are securely in place.
- The unloading equipment and unload gates function correctly and are closed.
- The working areas surrounding the bin are clean and clear of clutter.
- Check electrical performance and install lockouts (if needed) on equipment.
- Any temperature cables, if used, must be fastened to floor according to the manufacturer's recommendation to prevent displacement during filling.
- Know who or where to call for immediate help in case of an emergency or injury.

4.3.1. On larger bins, filling in several stages as described in Figure 11 is required to prevent uneven settlement. These instructions are general guidelines. Follow the civil engineer's instructions on initial filling.

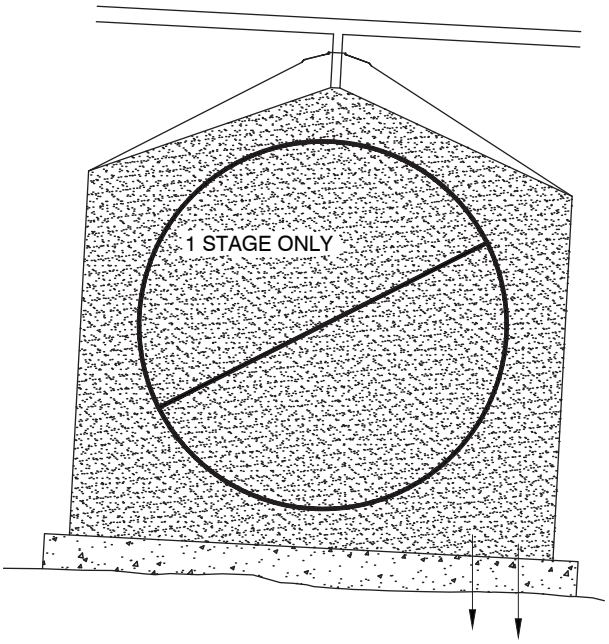
4.3.2. Maximum uneven settlement (deviation) after filling the grain bin (includes overall concrete deviation before bin erection) (see figure 7):

- For 60 ft. diameter and smaller: 1 ½ in. MAX.
- For larger than 60 ft. diameter: 2 in. MAX.

4.3.3. **IMPORTANT COMMERCIAL BIN INFORMATION:** Behlen Mfg. Co. requires stage loading to prevent excessive uneven differential settlement after first initial fill. Behlen Mfg. Co. recommends that for first stage, the grain bin be filled to 1/3 of eave height. It would then take 10 days for desired consolidation to occur. For the second stage it is recommended that the grain bin be filled to 2/3 of eave height. It would then take another 10 days for the desired consolidation to occur. Then the final 1/3 may be filled (see Figure 11).

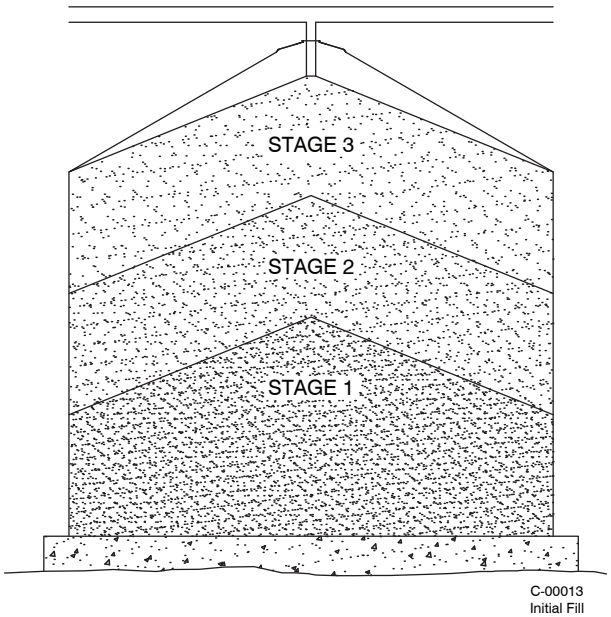
4.3.4. **IMPORTANT FARM BIN INFORMATION:** If the eave height is greater than bin diameter, the bin should be filled in two stages. The first stage should be to the height of the bin's diameter. Take 10 days for consolidation to occur, and then continue to fill the rest of the bin. If the height is not greater than the bin diameter, the initial fill can be completed in a 24-hour period.

INCORRECT



Filling taller larger bins with 1 stage only may cause uneven soil bearing pressures and off-centered settlement of bin.

CORRECT



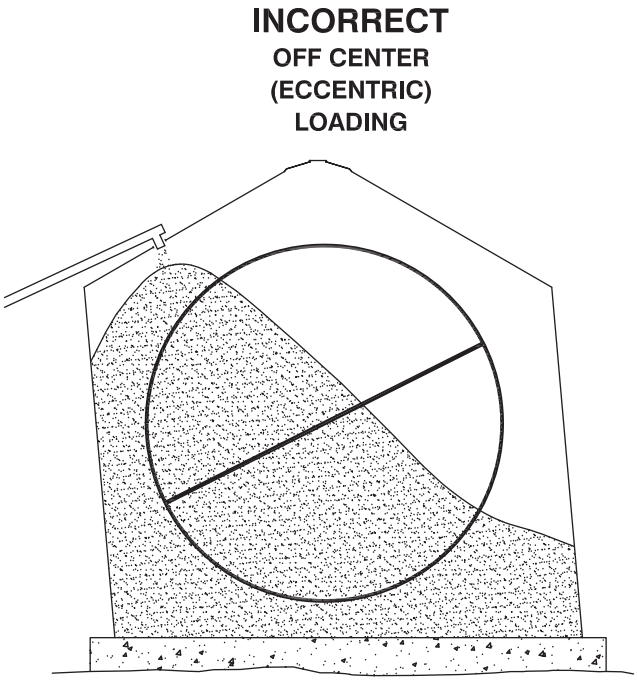
Filling taller larger bins in multiple stages will allow proper settlement.

Figure 11. Initial fill on taller larger bins.

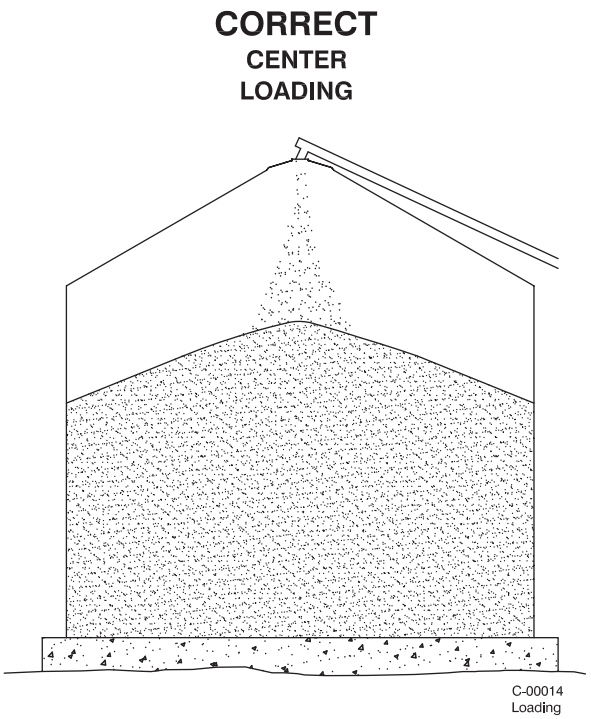
4.4. Loading The Bin

4.4.1. CHECKLIST FOR FILLING THE BIN

- Check that the bin has been cleaned after the last filling.
- Check that unloading equipment is functioning correctly.
- Close all intermediate gates.
- Place power sweep auger, if so equipped, over intermediate sumps.
- If temperature cables are used, attach them to the floor as specified by the manufacturer's recommendations.
- Make certain that everyone is out of the bin before filling the bin.
- Shut the sidewall door(s) properly. The inner door panels must be closed, sealed, and latched.
- Fill only through center peak ring.
- Know the maximum capacity of your bin. Overfilling may cause bin failure. Use spout /chute lengths to prevent overfilling.
- Grain must be center filled and not allowed to be pushed horizontally to one side of the bin or filled off center (see Figure 12).
- Continue to fill the bin to the desired level based on its use.
- Fill to the roof eave level.



Off center (eccentric) loading on sidewalls can cause an excessive overturning moment at the base which may result in the bin leaning or tipping and/or sidewall stiffener buckling.



Behlen grain bins must be loaded through the center of the roof cap to have uniformly distributed grain inside the bin.

Figure 12. Loading grain bins.

4.5. Unloading The Bin

4.5.1. To maintain uniform loads on the sidewalls, grain must be unloaded from the center of the bin. The center sump must be opened first. Intermediate sump(s) must not be used until all grain is completely emptied through the center sump (see Figure 13).

4.5.2. **IMPORTANT: DO NOT Simultaneously Fill and Discharge.** Simultaneous filling and unloading results in grain behaving more like a fluid than granular material. Increased fluidic behavior of grain can cause increased sidewall loads. Service life of the bin can be drastically reduced and risk of structural failure, economic loss and personnel injury will increase by simultaneously loading and unloading.

4.5.3. Do not empty the bin through sidewall door or cut a hole in the bin sidewall. This will cause uneven load distribution and excessive down pressure that may result in grain bin failure.

4.5.4. Make certain there are adequate vents installed on the bin to prevent a vacuum from forming in the upper portion of the bin during unloading. The pressures on the roof caused by such a vacuum could damage or cause structural failure to the grain bin roof.

The following safety decal must be affixed next to the gate controls of all unloading sumps.

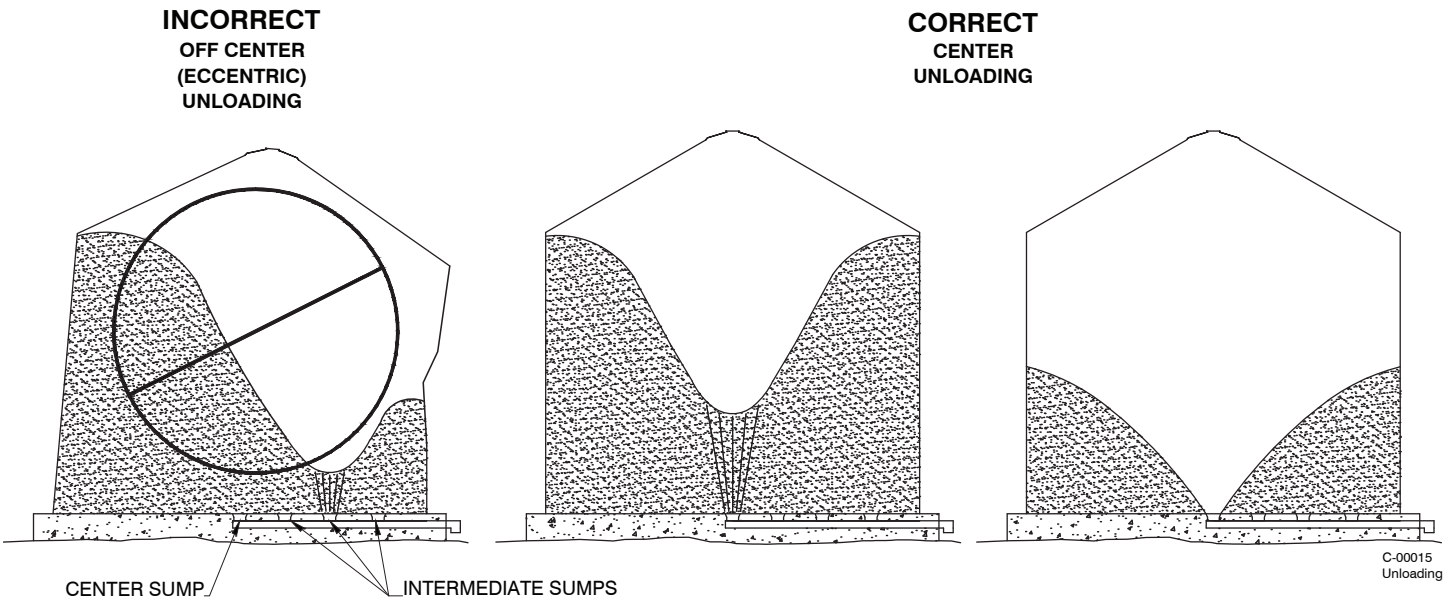
CAUTION

DO NOT UNLOAD GRAIN THROUGH SIDE GATES (NEXT TO SIDEWALL) UNTIL ALL GRAIN HAS BEEN REMOVED BY GRAVITY FROM THE CENTER OF THE TANK. BEHLEN GRAIN STORAGE TANKS ARE DESIGNED TO BE CENTER UNLOADED. FAILURE TO HEED THIS PRACTICE COULD DAMAGE THE STRUCTURE.

1688 443

WARNING

WARNING: Never vacuum out of the sidewall door unless all grain has been emptied, by gravity, through the center sump first, followed by intermediate sump(s)



Off center (eccentric) unloading at floor or wall can cause excessive down pressure and can result in sidewall buckling.

Behlen grain bins must be unloaded through the center sump until all grain has emptied through this sump. Then, and only then, can auxiliary sumps be utilized.

Figure 13. Unloading grain bins.

4.6. Sweeping The Bin

4.6.1. When inside the grain bin, performing cleaning or maintenance, perform LOCK-OUT and TAG-OUT procedures to disengage power to all unloading equipment power and to prevent reenergizing. **NEVER enter a bin when unloading equipment is operating, as you may become entangled in the sweep or the unloading auger! Failure to heed this warning may result in serious personal injury or death!**

4.6.2. **STEPS TO SWEEPING THE BIN**

- Be certain that no bridged grain or vertical crusting is evident.
- Start to sweep the bin after all grain has flowed by gravity through center and intermediate sumps.
- If you have a multiple-pass sweep auger, lock out the inner sweep system before adding the outer sweep section (see figure 14). Have another person present.
- If the sweep auger fails to operate, call the sweep auger manufacturer.
- Return the sweep to original position over intermediate sump gates.

DANGER

Never enter bin while equipment is operating. Augers travel at increasing speed when bin is emptied. Failure to heed this warning may cause serious injury or death.

- **Lock-Out/Tag-Out all equipment.**
- **Use a safety harness and safety line.**
- **Wear a dust respirator.**
- **Avoid the center of the bin.**
- **Station a person to help from the outside of the bin.**

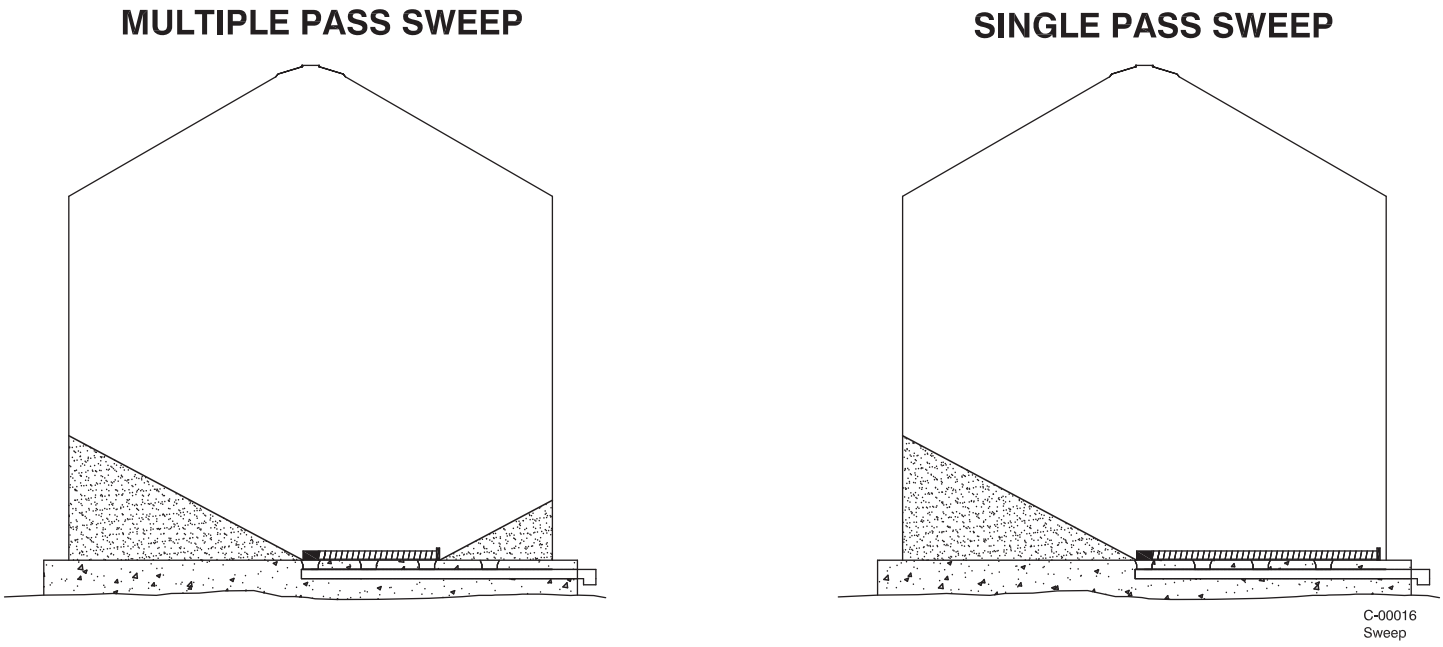


Figure 14. Sweep Auger Use in Grain Bins

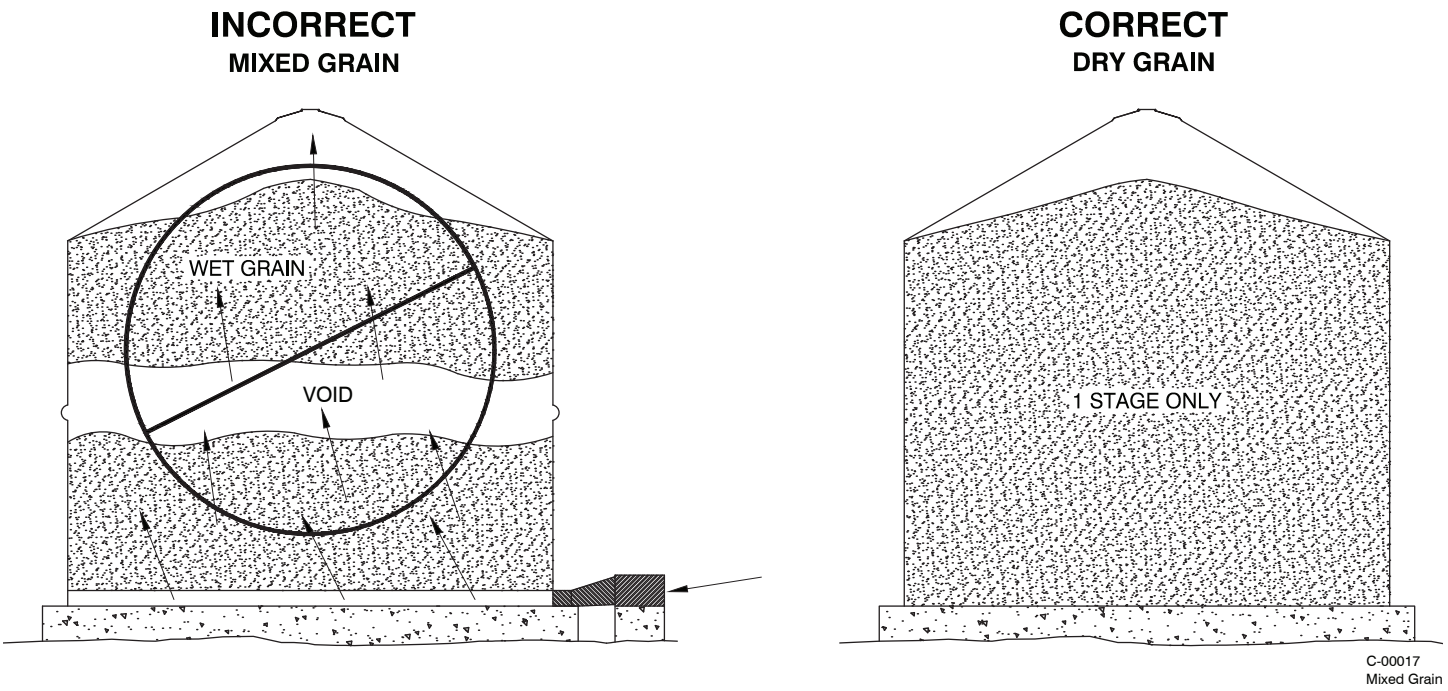
4.7. Material Stored

4.7.1. Storage bins are designed to store only dry, free-flowing grain, with a density of up to 52 lbs/ft^3, and that has been cooled. **Do not put grain exceeding 16% moisture in a storage bin.** Only drying bins using a stirring machine can hold a mix of wet and dry grain for a limited amount of time. **Note:** Buckling of sidewall sheets can occur due to grain on the bottom of the bin drying and shrinking. This allows wet grain above to be supported only by the bin sidewall. Failure generally develops in the area of drying front (see Figure 15).

4.7.2. Do not mix quantities of wet grain with dried grain unless it's in a bin with an operating stirring machine. Partially dried grain shrinks and causes voids. Sidewall and stiffeners can buckle under immense pressure. Standard storage bins are not designed for storage of high-moisture grains.

4.7.3. High moisture grain **(over 15-16%)** will go out of condition quickly. Grain that is out of condition can spoil and will not flow freely and may cause other problems. Only bins designed for drying may hold high moisture grain for a short period of time. No Behlen grain bin is designed to hold wet grain for long periods of time.

4.7.4. To guard against excess sidewall loads caused by grain kernel expansion, **grain bins must be managed to prevent grain moisture from increasing above 16% during storage. In addition, do not have grain moisture content variations of more than 2 moisture points in a storage bin (see Figure 16). See the following warning discussing frozen grain in bins.**



Grain partially dried, shrinks and causes a void. Buckling can occur within the sidewalls and stiffeners.

Behlen storage bins are designed to store dry, free-flowing grain with a density of up to 52 lbs/ft^3. They are not designed for storage of high moisture grain.

Figure 15. Mixed Grain

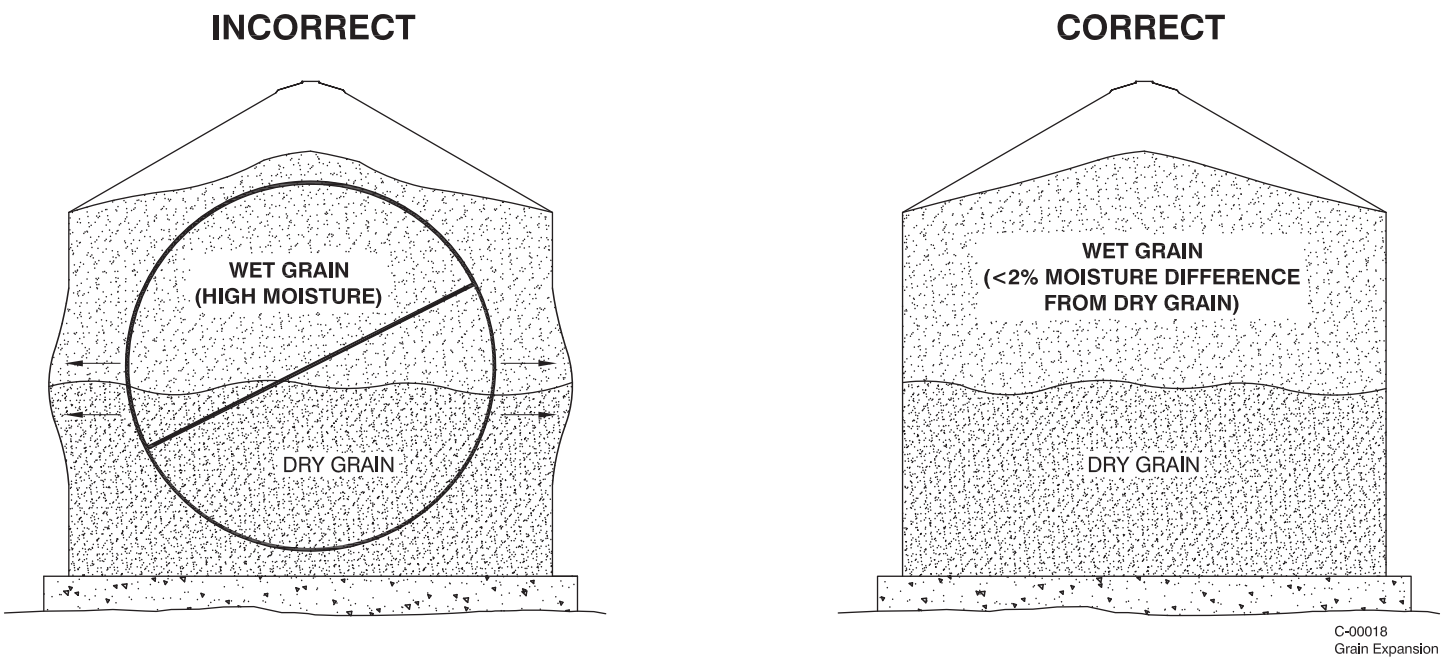


Figure 16. Grain Expansion

4.7.5. **DO NOT FREEZE GRAIN** due to problems it can create, particularly during warming in larger bins. Condensation during aeration can be a problem in grain cooled below freezing. It will be difficult to warm grain in the spring without condensation forming and freezing into ice. Frozen chunks block aeration warming cycles and grain unloading. **Condensation also re-wets grain and can cause sudden bin failure and collapse due to expansion of kernels.** If grain does freeze, begin thawing it once the average outdoor temperature is 10° to 15° degrees F (6° to 8°C) above grain temperature. Follow steps outlined in segment below. **Failure to follow instructions for thawing frozen grain may result in sudden bin collapse and failure (see Figure 17).**

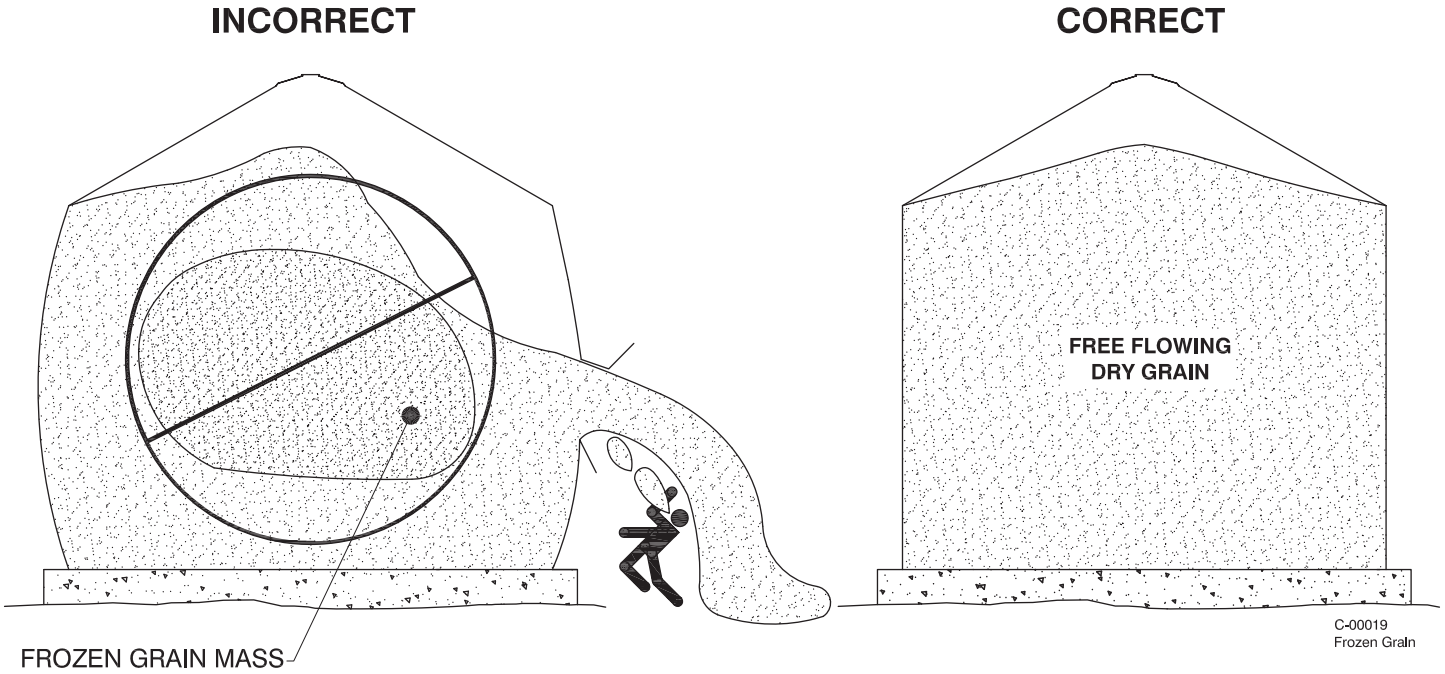


Figure 17. Frozen Grain

WARNING

Damage from frozen grain may cause sudden structural failure and collapse, which may result in personal injury or even death. Frequently monitor and inspect bin. Follow operation and maintenance instructions described in this bin manual.

4.7.6. **Managing Grain in Spring and Summer** - Start the fan when the average outdoor temperature is within 10° to 15° F (6° to 8° C) above the grain temperature. Once the warm-up cycle is started, do not turn the fan off. Stopping the warming front before a cycle is completed encourages condensation of moisture and spoilage. As outside temperatures continue to warm, repeat this cycle as often as needed until average grain temperature is 50° to 60° F (10° to 16° C). **Maintain the grain temperature within 15° F (8° C) of the average monthly temp.** Do not warm the grain to summer temperatures above 60° F (16° C) in the southern U.S. or 50° F (10° C) in the northern U.S. due to insect infestation and other storage issues. In some instances it may be desirable to fumigate the stored grain. Consult your local extension service for proper and safe fumigation techniques.

4.7.7. Filling grain up against roof sheets may cause the roof to expand outward and fail. Opening a roof door when a the bin is overfilled will cause grain to spill out, possibly resulting in someone being caught in grain flow (see Figure 18). Check for overfilling by tapping against roof door cover before opening. A hollow sound means it's acceptable to open the door. A solid sound means grain is against it. **DO NOT OPEN roof door when there is grain against it.** Unload the bin to get grain away from the roof. Be certain ladder cages and platform handrails are in place and correctly installed. See the Spout/Chute Lengths section of this manual.

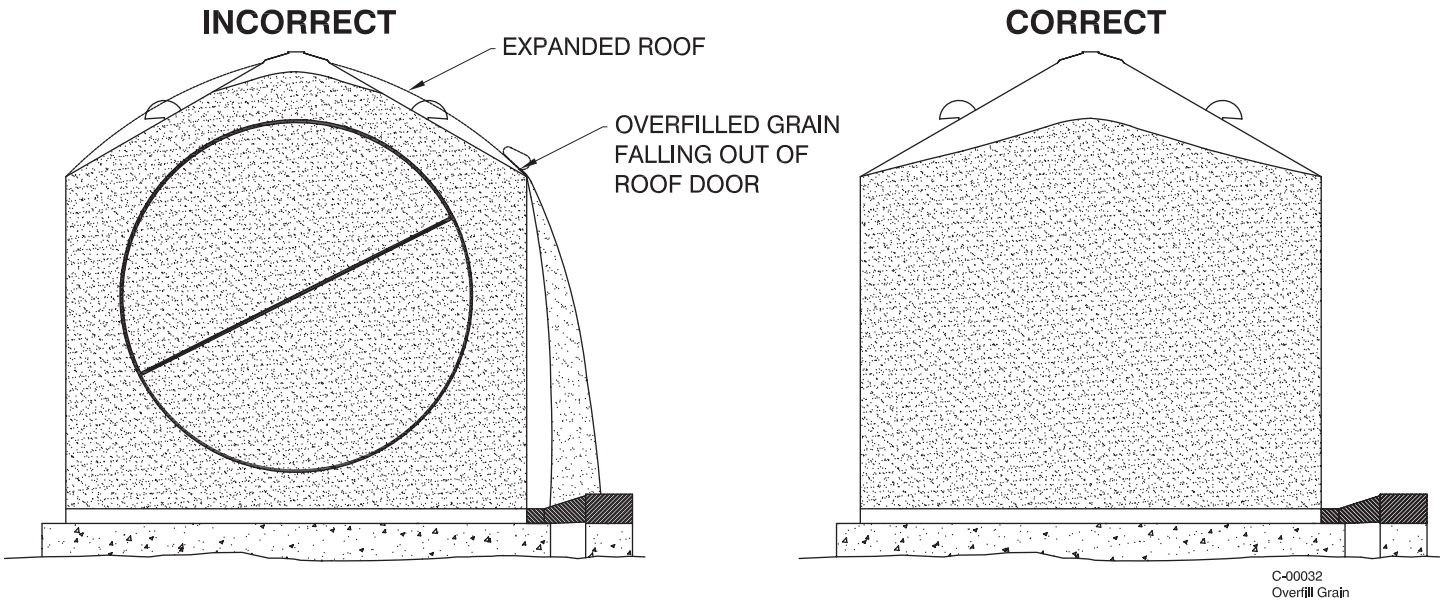


Figure 18. Bin overfilled with grain.

4.8. Stirring and Recirculating Augers

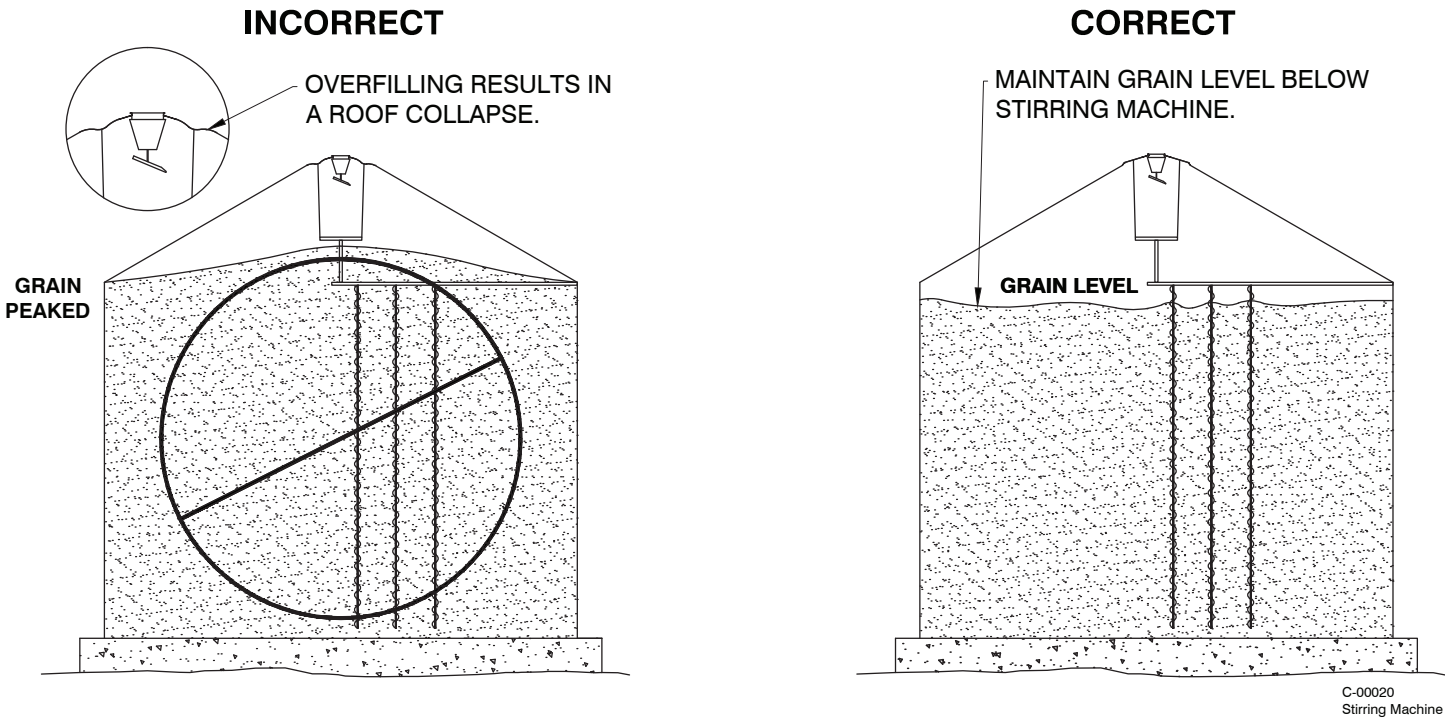
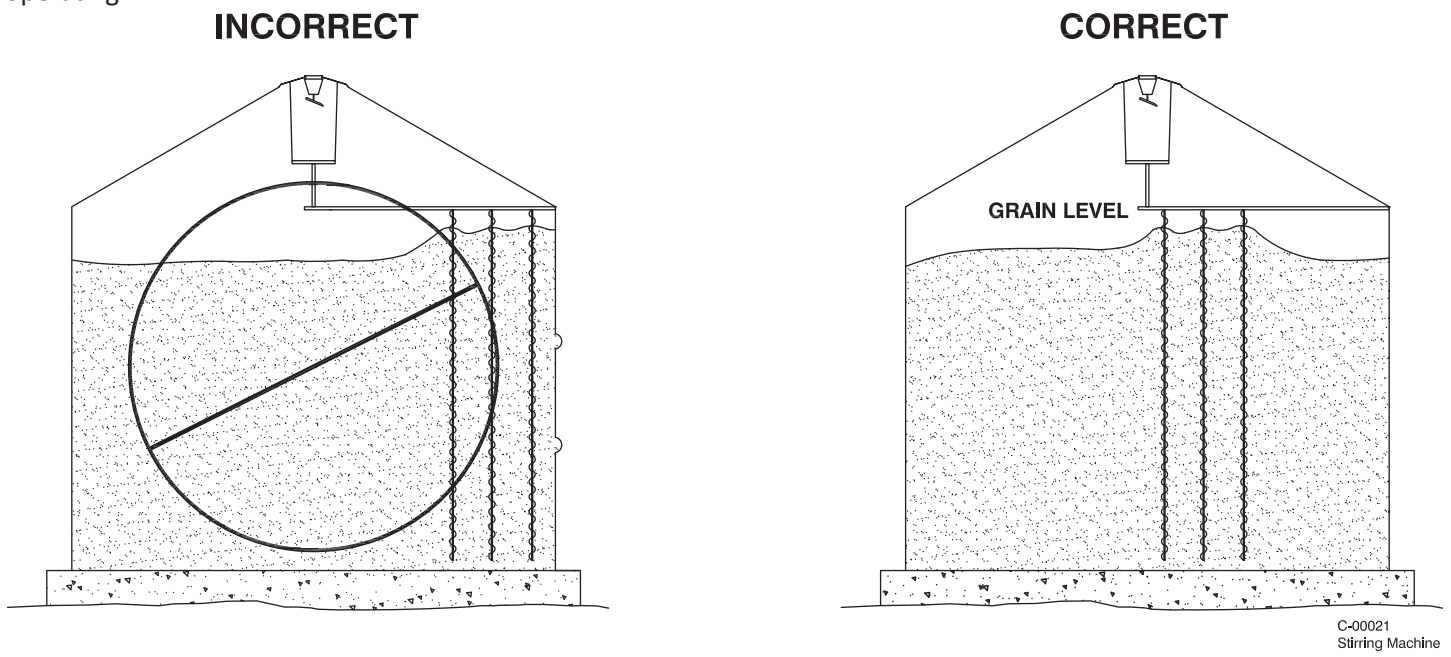


Figure 19. Overfilling with stirring augers.

4.8.1. Stirring augers should be run continuously while filling. Do not fill bin with grain above stirring auger. Grain should be level 30" below the eaves. Roof peak ring failure can occur, especially during unloading (see Figure 19). Down augers should be free prior to start-up. Please read the stirring auger manufacture's operation manual before operating.

4.8.2. When using stirring augers, do not operate them or start them near the bin sidewall (see Figure 20). Stirring augers must be kept at a safe distance from the bin sidewalls. Contact you Behlen Mfg. Co. Engineering to see if additional wall stiffeners or floor supports are required.



Don't start up the stirring devices screws near the wall. The sidewall and stiffeners could buckle if the screws are against the sidewall. Screws should be "Free" prior to start-up.

The stirring device screws should be started near the center of the grain bin.

Figure 20. Staring stirring augers.

4.9. Ventilation

4.9.1. Grain bin roofs are not designed to withstand excessive air pressure differentials. General ventilation recommendations are 1 ft^2 (0.093 m^2) of vent area for every 1,000 cfm (28.3 m^3/min). Maximum recommended pressure differential in the roof area is 1" w.c. (water column) Be alert to the possibility of frost build-up on air passage screens to a point of complete blockage. This may occur when high relative humidity, high grain temperatures, or high grain moisture levels are combined with freezing or near freezing temperatures. Running fan(s) during these conditions can create frost build-up and airflow blockage causing the roof to dome. Precautionary measures must be taken to prevent this condition.

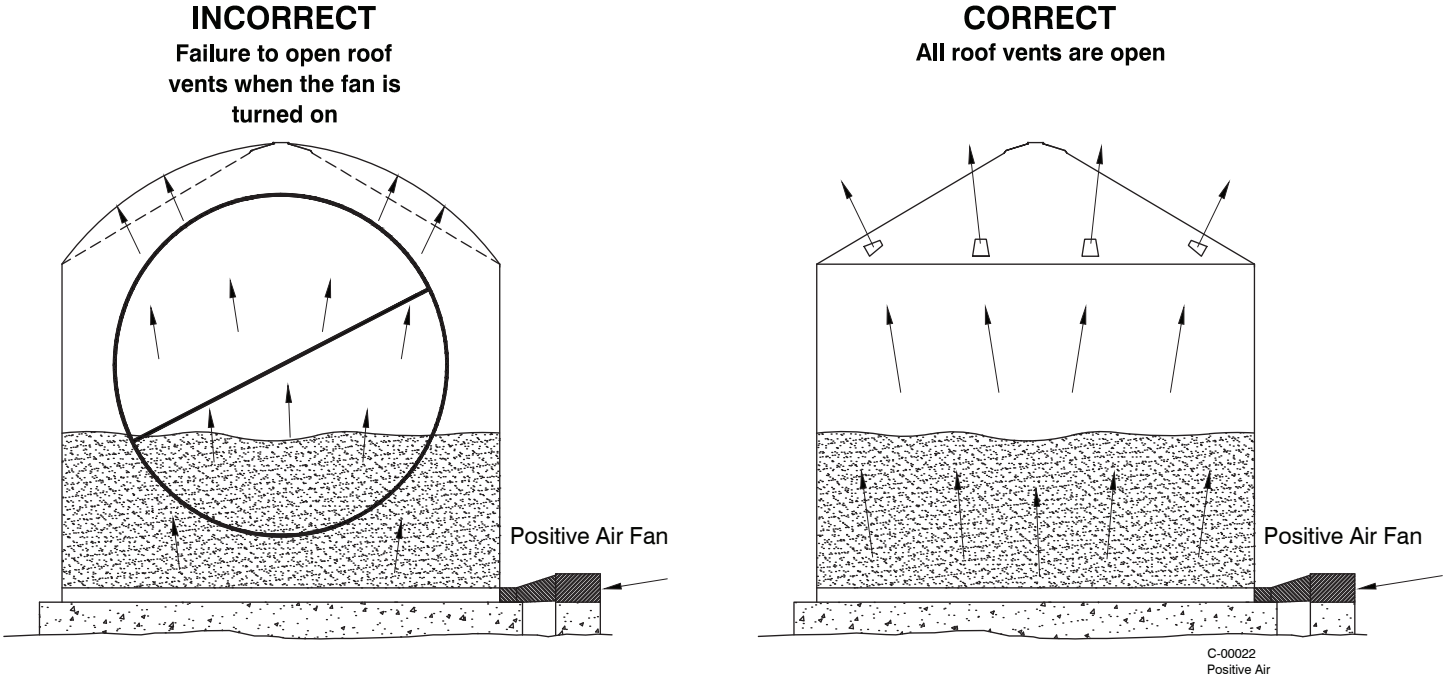


Figure 21. Positive air pressure.

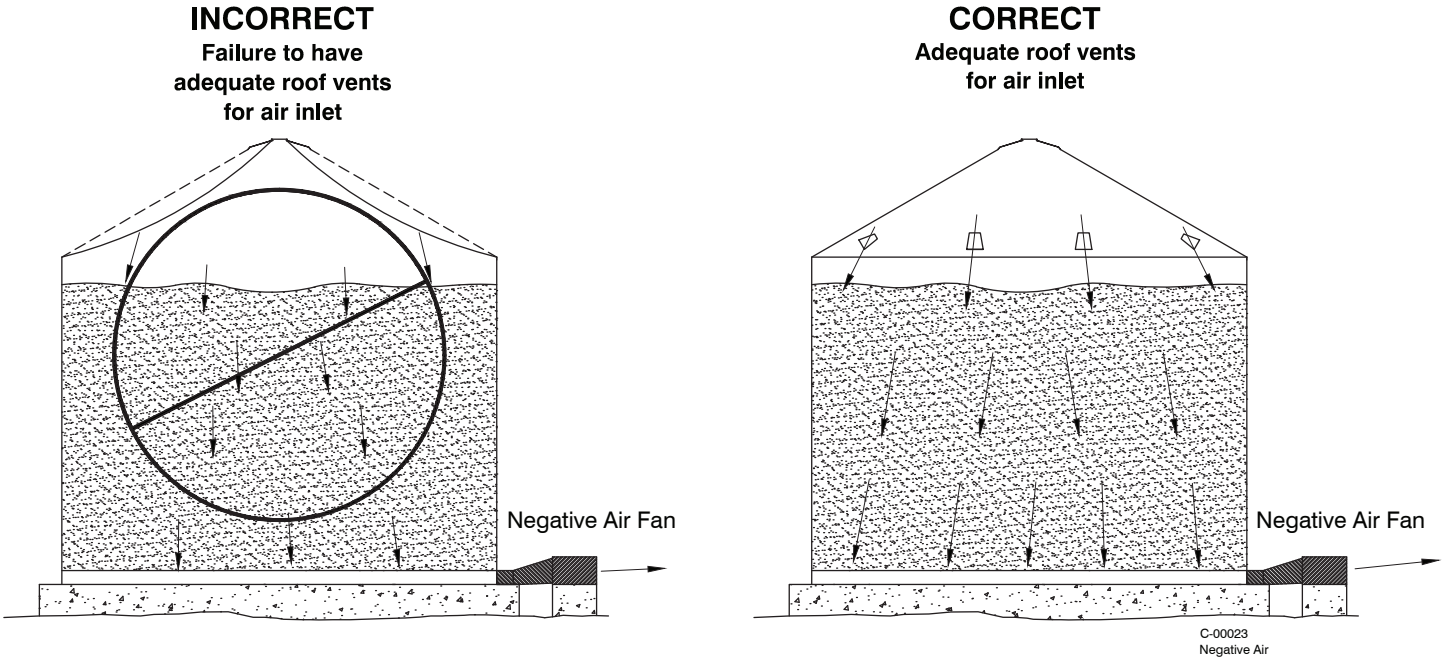


Figure 22. Negative air pressure.

4.9.2. Do not pile grain against the roof. Grain piled too high will block the roof vents. Blockage of the roof vents will restrict the effective vent area by 95-98%, virtually eliminating the vent area. The area above the surface of the grain must allow for free movement of air to the vents (see Figure 23). Be aware of the possibility that the screens of the roof vent may collect moisture and freeze shut. This can happen when high relative humidity, high grain temperatures, or high grain moisture levels are combined with freezing or near freezing temperatures. Do not run the fan(s) during these conditions. Running the fan(s) during these conditions can create frost build-up and airflow blockage causing the roof to dome.

4.9.3. If negative air roof fans are used in the roof vents, they must operate simultaneously with the positive air fans at the base of the bin. They need to be wired so that negative air fans start a few seconds after the positive air fan. This is done so the air has enough time to be pushed through grain to replace the air that leaves through the roof. Failure to do this could result in roof failure (see Figure 24).

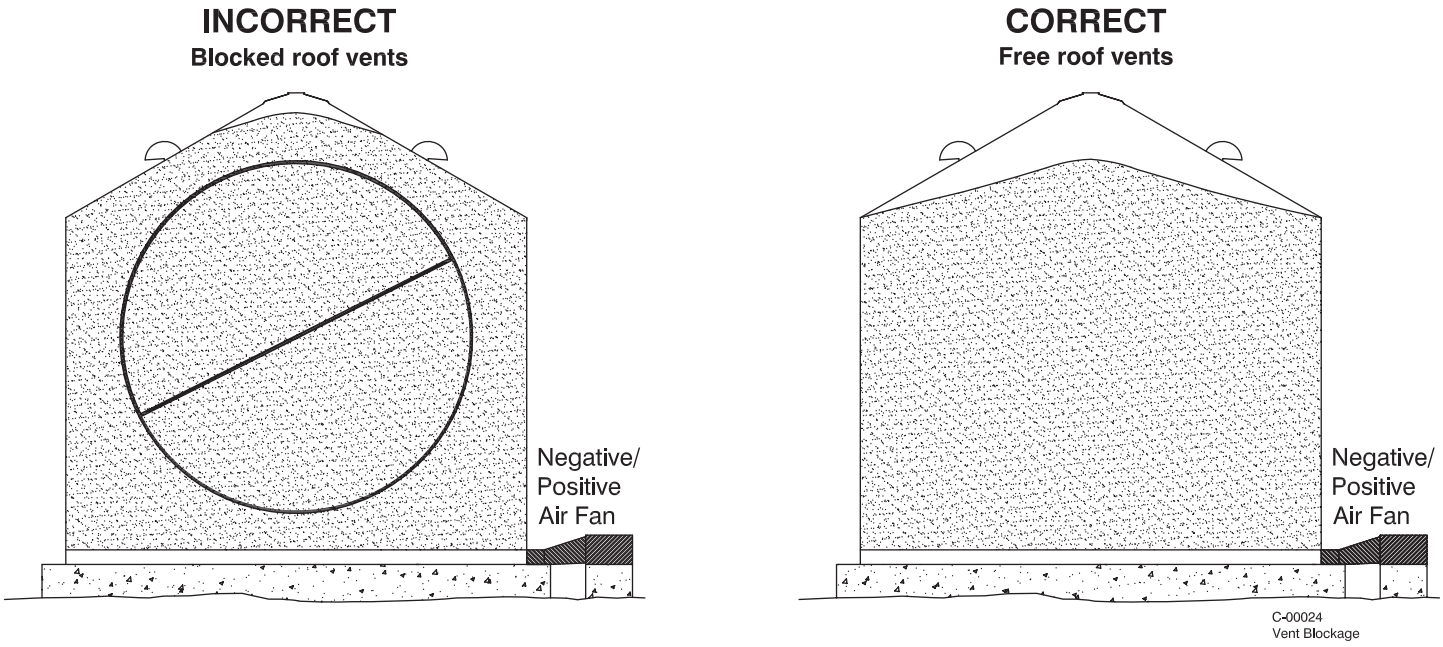


Figure 23. Blocked vents.

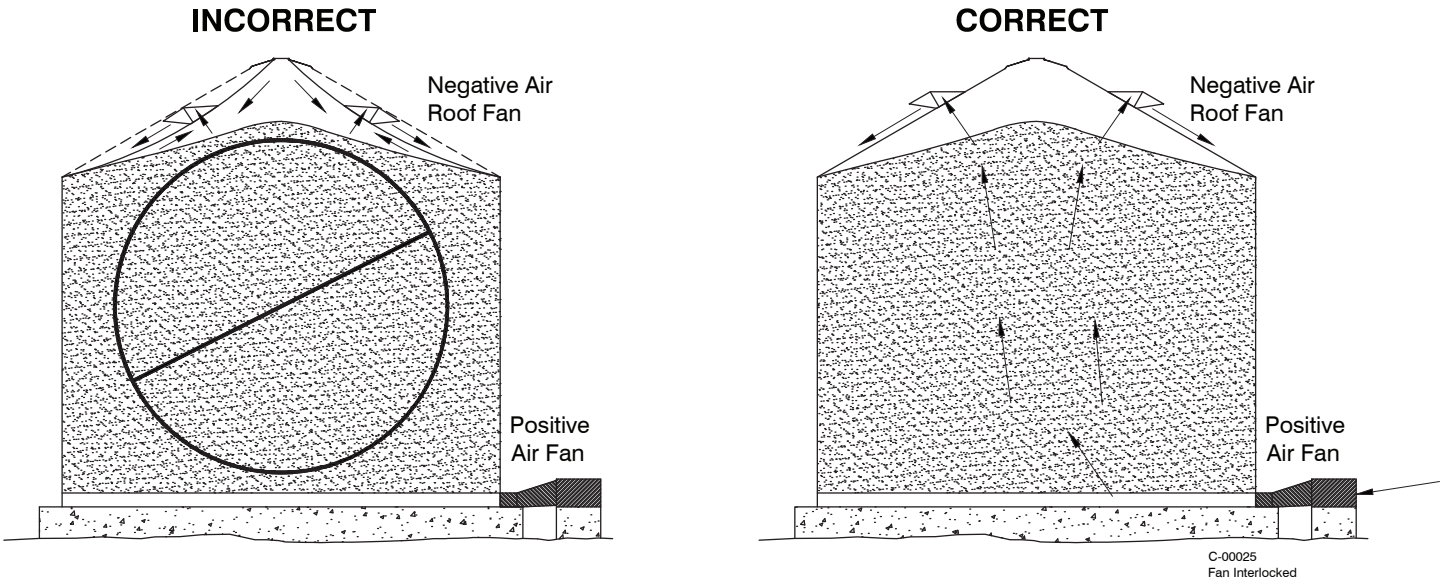


Figure 24. Interlocking fans.

4.10. Temperature Cables

4.10.1. Refer to the Behlen erection instructions for support requirements and necessary items for temperature cables. Depending upon the series and model of bin you have, temperature cables are attached to the appropriate roof attachment bracket designed for that type of bin. Improper installation of temperature cables may cause damage to roof due to down-pull when filling, settling, and emptying of grain. Tie cables to the floor or concrete with breakable filament (fishing line), if a sweep auger is in use. Refer to the cable manufacturer installation instructions to see other methods of attachment of the cable to the floor of the bin (see Figure 25).

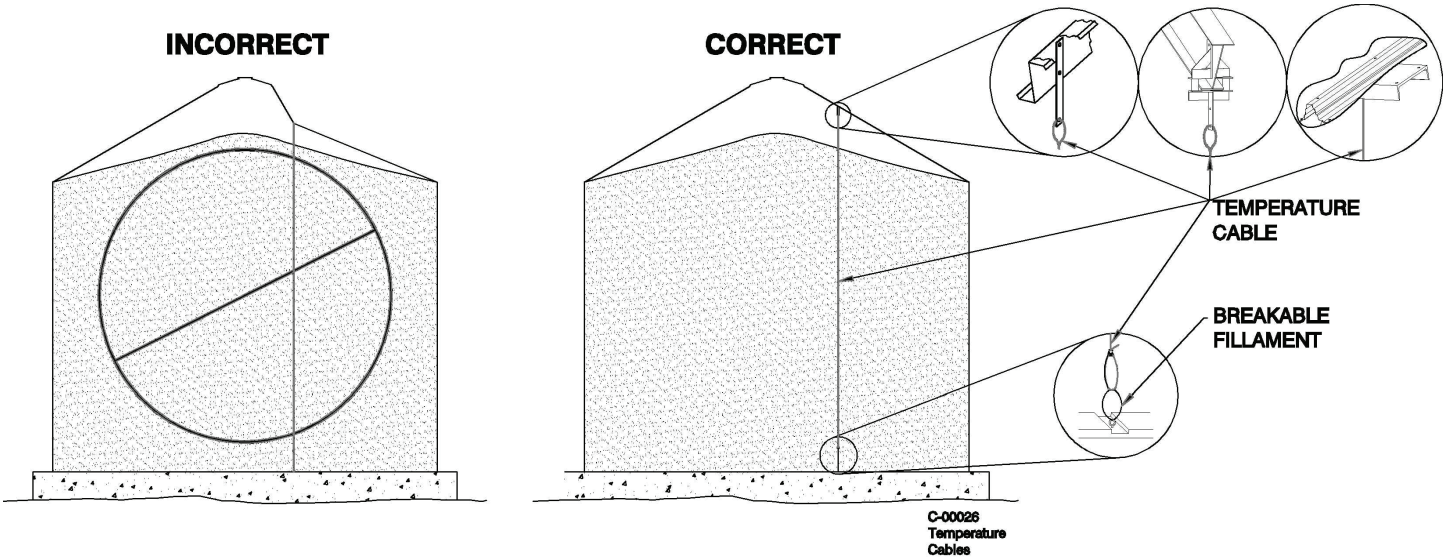
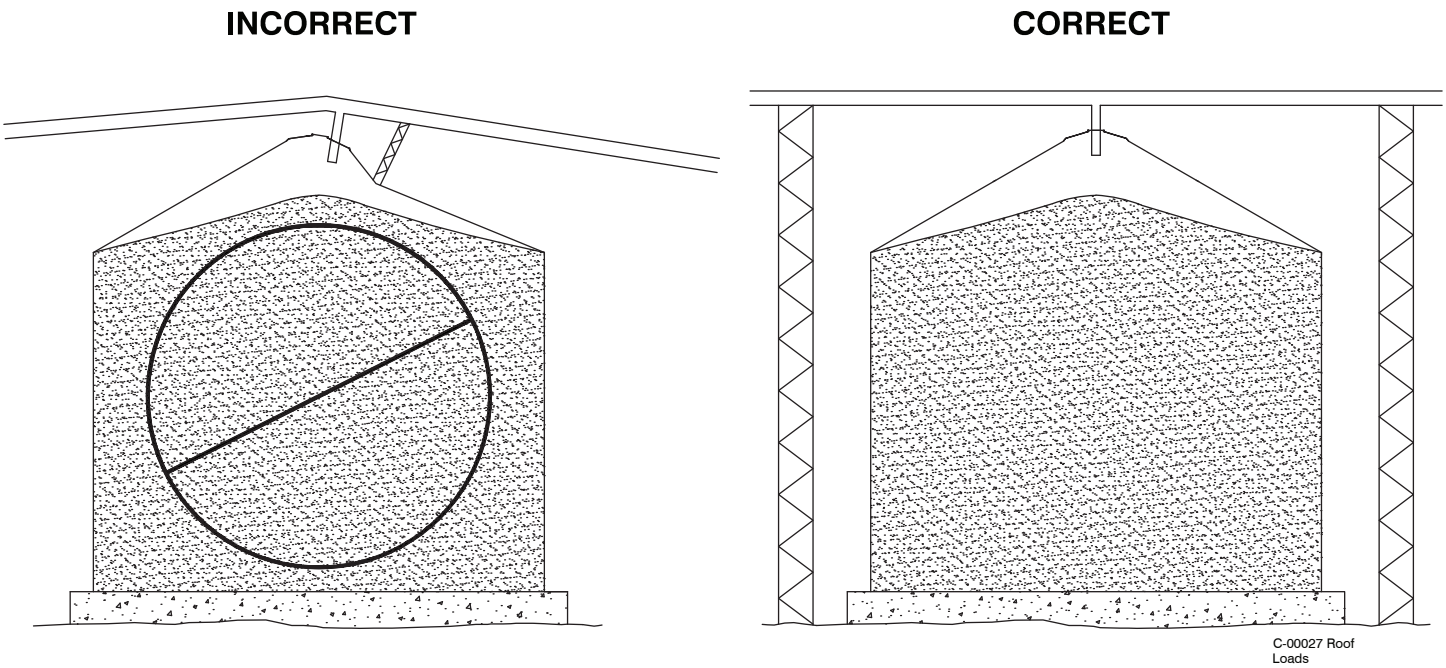


Figure 25. Temperature cable attachment.

4.11. Loads Concentrated on Roof

4.11.1. **IMPORTANT:** Loads created by additional components must not exceed the design ratings for the specific Behlen bin. Load ratings for standard Behlen bins are listed in the grain structure specifications and the Behlen quote. Ratings for special Behlen bin roofs are specified on the quotation form and erection instructions. Peak loads are designed to handle loads in excess of the roof snow loads. These include spouts, catwalks, conveyors, spreaders, stirring augers, and other equipment. If multiple items are supported by the roof the sum of their weights must be used to check capacity.

All concentrated loads on roof must be UNIFORMLY DISTRIBUTED to the peak ring. Use of separate support towers may be needed to properly distribute overhead loads. Please contact Behlen Mfg. Co. Engineering for specifically designed sidewall supports (see Figure 26).



Unevenly placed roof peak loads and loads concentrated on the roof other than the roof peak could cause roof failure.

External loads shall be uniformly loaded onto the peak roof ring and towers or sidewall supports.

Figure 26. Roof load placement and support.

4.12. Stiffener Loads

4.12.1. **INCORRECTLY INSTALLED**

- Gaps between the stiffeners
- Sidewall buckling
- Stiffeners not resting on the concrete footing
- Concrete not level

4.12.2. **CORRECTLY INSTALLED**

- No gaps between the stiffeners
- No buckling
- Stiffeners resting flat on the concrete footing
- Level concrete

4.12.3. The stiffeners carry the vertical wall loads on the bin, therefore serving as columns for the structure. They should be attached to the sidewall and each other exactly as described in Behlen's Erection Instructions. They must form a continuous column from the eave to the concrete floor. Do not cut stiffeners for any reason. The stiffeners shall rest firmly against each other at all splice joints and shall also rest firmly on the floor (see Figure 27).

4.12.4. If a situation occurs where a stiffener rests over a tunnel, or a fan transition is too large to fit between two stiffeners, adequate support must be provided that will continue to support the stiffeners through the tunnels. Contact Behlen Mfg. Co. Engineering for support recommendations. It is very important that the bottom stiffener rest on a concrete pad.

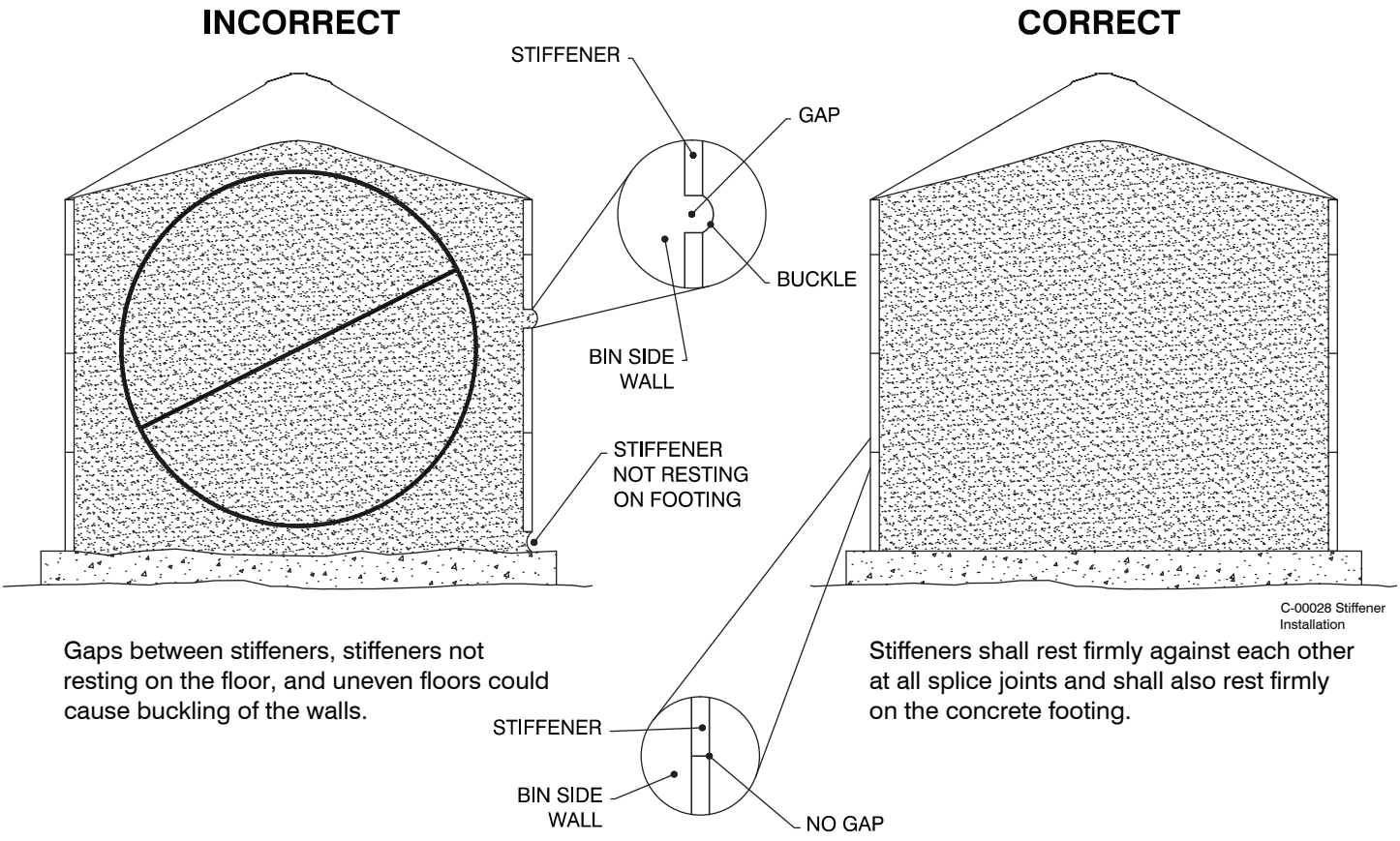


Figure 27. Stiffener installation.

4.13. Side-Draw Flume System

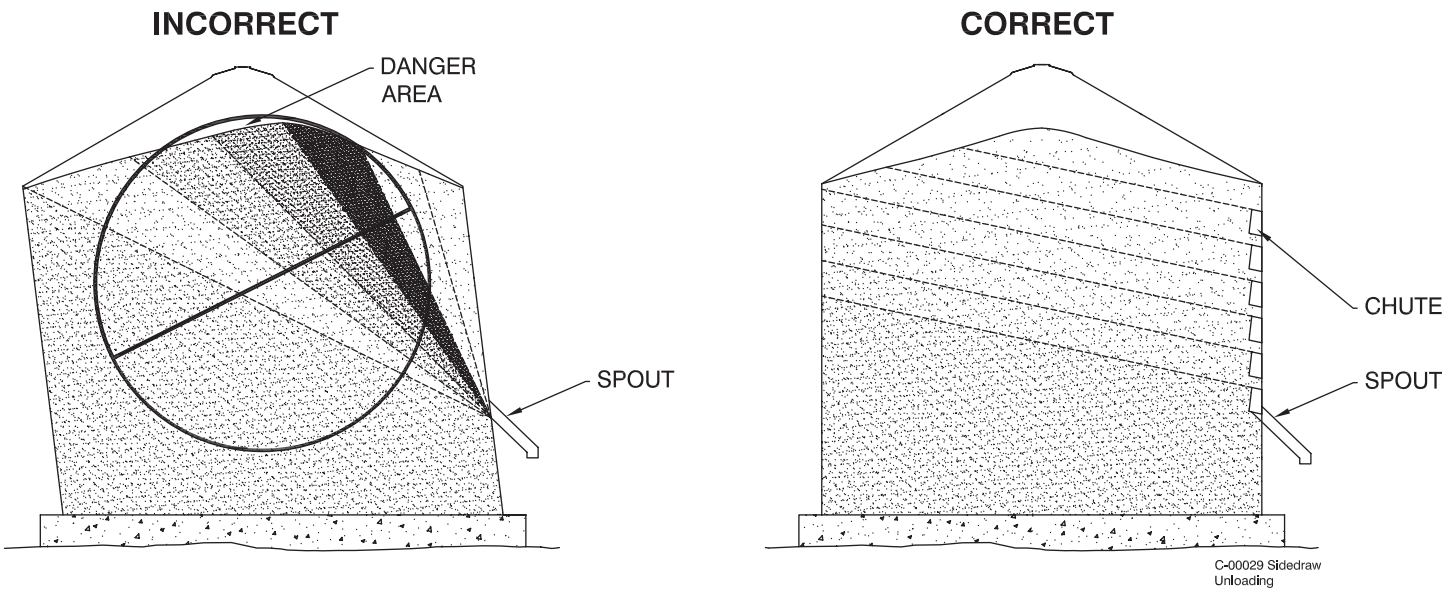
4.13.1. Side-Draw Installation

- Side discharge is only permitted in Behlen commercial bins when a Behlen manufactured side-draw flume system has been installed. No corrugated steel bin should be unloaded through the sidewall without installation of a side-draw system and the permission of the manufacturer (see Figure 28).
- Interior baffles channel grain from the top storage to the discharge chute because grain flows off the top of the grain surface when withdrawn from below (funnel flow).
- The use of a flume system should be reviewed with a geotechnical or foundation engineer. Geotechnical investigations or past experience may indicate significant foundation level soil variations or a site propensity toward differential settlement, under these conditions side-draw usage may be prohibited or severely restricted.
- Installation of a flume system may require installation of additional wind rings and larger diameter anchor bolts. Installation of multiple systems requires approval of Behlen engineering.
- A side-draw system should not be the only discharge system available. A standard center discharge and conveyor must be installed. A side-draw system is not intended to be used as a continuous fill/empty system.
- **NEVER add a side-draw to existing bins without consulting a Behlen engineer. Also, consult a Behlen engineer before installing on M-24 and larger bins.**

NOTICE

IMPORTANT GUIDELINES FOR SIDE-DRAW USE!

- Intended for use with dry flowable grain only. Do not use a side-draw system with poorly flowing and dirty grain products.
- Side-draw systems are not to be considered the primary outlet. Standard center sumps and conveyors should be installed. A side-draw system is not intended to be used as a continuous fill/empty system.
- Filling should not be occurring at the same time as grain is being withdrawn through the side-draw flume system.
- In multiple side-draw systems, only one side-draw system may be used at a time.
- Side-draw systems will leave grain in a sloped position, creating off center loads. **NOTE: Before refilling, unload through center sump so that the grain reaches equal wall heights around entire bin. Grain must be level or in a cone down position before adding more grain. See the following section.**
- Prolonged storage of grain in the sloped condition produced by the side-draw discharge may accelerate differential settlement resulting in deformations of the bin/silo.
- After using the side-draw system, the sloped grain should be returned to near level by use of a center discharge. This will help prevent differential foundation settlement and bin deformations.



Side discharge without an installed side draw system could cause an unbalanced grain condition.

Use of a side draw system is the only allowed side discharge permitted.

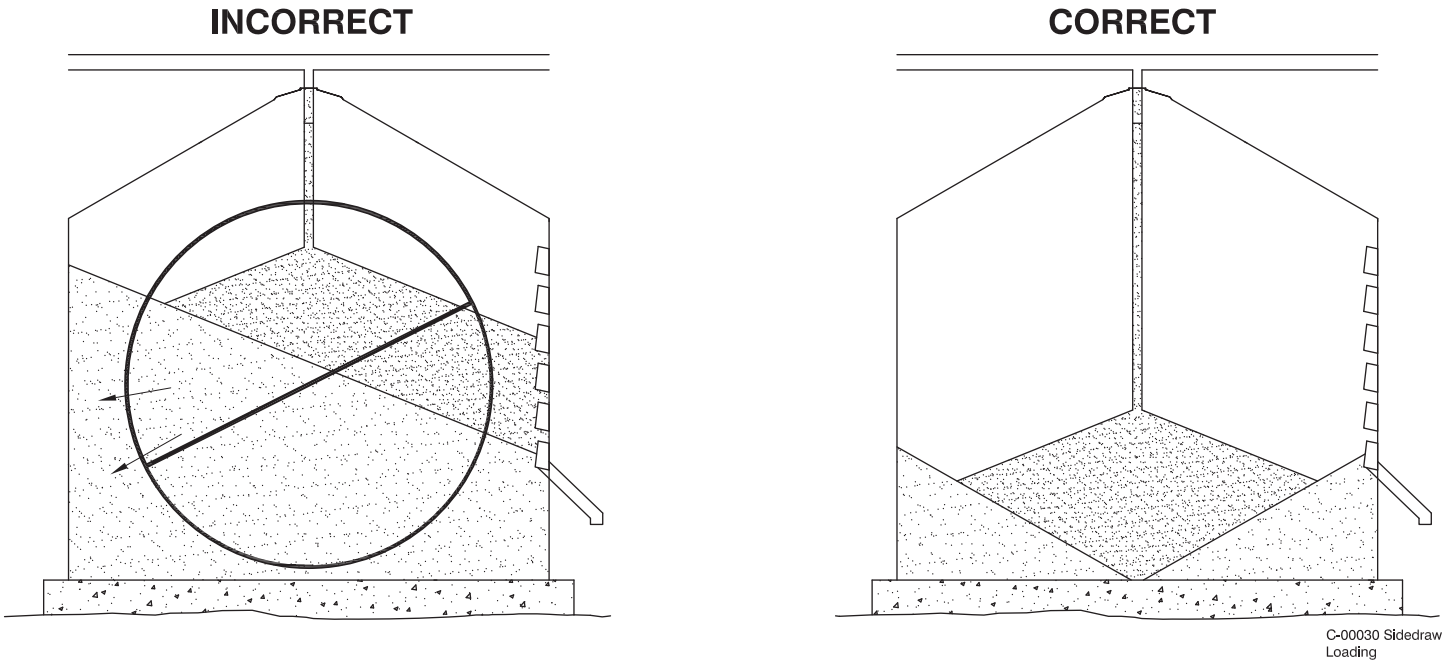
Figure 28. Sidedraw unloading.

4.14. Refilling After Side-Draw System Use

4.14.1. Before a bin can be refilled after being even partially unloaded with a side-draw system, grain needs to be leveled or completely emptied through center sump. It is important that sidewall pressure is equal before refilling. Behlen Mfg. Co. recommends unloading grain through center sump until grain reaches equal wall heights so that an inverted cone is formed in the remaining grain. Once an inverted cone is achieved and sidewall pressures are equal, it is safe to refill bin through center peak ring (see Figure 29).

4.14.2. Note: The design of baffles can be used only with a side-draw system. Intermediate sumps located near side-draw flumes cannot be used as the primary outlet. Unloading must be done correctly through side-draw, center sump, and then intermediate sumps. **Never use intermediate sumps until all grain has flowed by gravity through center sump. Unloading through intermediate sump initially will cause uneven load distribution that may cause bin failure.**

4.14.3. Before a grain bin can be refilled, it should be completely emptied. Total clean-out of the bin prevents build-up of compacted grain, which cannot be emptied by gravity flow. Also, be certain no grain is matted to the sidewall. If matting occurs, remove moldy grain with a wire brush and repaint. Since grain cannot be completely emptied using a side-draw, grain must be emptied through center sump to form an inverted cone (cone-down position) in the remaining grain. Formation of inverted cone will help evenly distribute lateral forces on bin sidewalls.



Refilling without grain being level or in a cone-down position will create uneven sidewall pressures and may cause bin failure. Prolonged storage of grain in this condition may accelerate differential settlement resulting in deformations of the bin.

Before refilling, unload through the center sump so that the grain reaches equal heights around the entire bin. Grain must be level or in a cone-down position before adding more grain.

Figure 29. Grain bin re-filling after side-draw use.

4.15. Hopper Bottom Bins

4.15.1. **IMPORTANT: Hopper bins are not intended for drying. Grain should be dry and cool when put in a hopper bin for storage.** Maximum allowable storage time for wet grain (over 16%) in a hopper bin may be only one to two days. Storing high-moisture or spoiled grains may deteriorate the galvanized coating of the bin. High-moisture grain may also cause grain to crust. Probe the stored grain regularly to check its quality. Store only free-flowing material. Do not store hard-to-flow material such as soybean meal or other materials that will cake or crust. Unloading spoiled grain at a high rate of speed, that is bridged or vertically crusted, may cause uneven pressures resulting in hopper tank failure. Check the inside of the bin while unloading to ensure no vertical crusting is evident.

4.15.2. Before filling the hopper-bottom bin, be certain no objects or old grain remain inside. Thoroughly clean the hopper bottom after each use and be certain the bottom unload gate is completely closed. Keep all persons out of bin except when absolutely necessary. Refer to the safety section for general guidelines on entering bins, ventilation, and using safety harnesses.

4.15.3. Loading must be done through the peak ring. Off-center filling may cause excessive loads, which may result in the bin leaning and/or sidewall stiffener buckling. Unloading must be done through the outlet of the cone only. **Note: Never cut holes in the bin sidewall.** Off-center unloading will result in excessive down pressure and uneven load distribution that may cause sidewall buckling. **Also, if the hopper-bottom bin is sealed tight at the eave, the peak ring cap and manhole must be opened when unloading grain.** Lack of proper roof openings for rapid unloading can cause the roof to be pulled down.

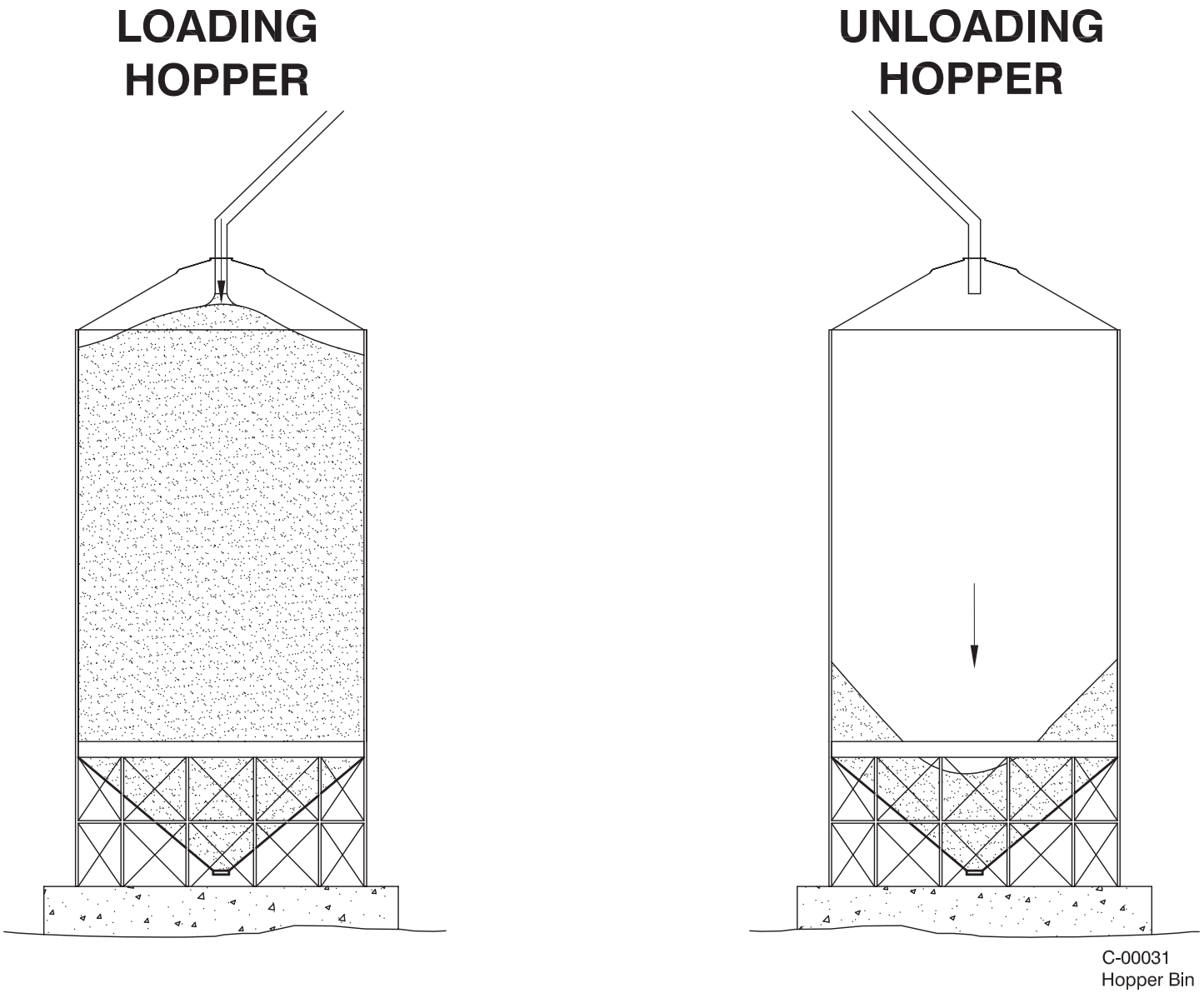


Figure 30. Hopper bins.

5. Managing Stored Grain

5.1. Basic Principles

5.1.1. Grain will deteriorate faster as temperature and moisture content increase. Using corn as an example, Table 1 illustrates how fast grain can spoil even with proper aeration.

5.1.2. Corn can only be stored for a limited time which depends on the moisture content and temperature of the grain. The allowable storage time is based on the length of time corn can be stored before losing 0.5% of dry mater (see Table 1). With this amount of dry matter decomposition, it is assumed that the corn loses some quality, but maintains its market grade. For each 10° F (5° C) increase in temperature, storage time is cut in about half when held at a given moisture content.

5.1.3. Grain moisture content will change with relative humidity of the surrounding air and the grain temperature. Table 2 shows the equilibrium moisture content of corn at various temperatures and relative humidities. Contact your local extension office for information on other grains.

5.1.4. Under certain conditions (see Table 2), no matter how long the fan is operated, grain may not reach the desired moisture content that will allow it to be stored without spoilage. Keep in mind, air temperature and relative humidity are not constant. Use daily average for determining final moisture content.

5.1.5. Table 3 shows the recommended aeration when storing grain for short periods in a wet holding tank at various moisture contents. This will only hold grain for a length of time shown in Table 1. If no aeration is provided, grain may deteriorate much faster due to regions of higher temperatures that may begin to develop, producing heat and moisture that accelerate deterioration. The purpose of aeration is to reduce high temperature areas and to keep all grain at a constant temperature.

"Approximate" Allowable Storage Time (Days) for Cereal Grains						
Grain Temp (°F)	30°	40°	50°	60°	70°	80°
Grain Temp (°C)	-1°	4°	10°	16°	21°	27°
M.C. (%)	Days					
14	*	*	*	*	200	140
15	*	*	*	240	125	70
16	*	*	230	120	70	40
17	*	280	130	75	45	20
18	*	200	90	50	30	15
19	*	140	70	35	20	10
20	*	90	50	25	14	7
22	190	60	30	15	8	3
24	130	40	15	10	6	2
26	90	35	12	8	5	2
28	70	30	10	7	4	2
30	60	25	5	5	3	1

Based on composite of 0.5 percent maximum dry matter loss calculated on the basis of USDA research at Iowa State University; Transactions of ASAE 3330337, 1972; and "Unheated Air Drying," Manitoba Agricultural Agdex 732-1, rev. 1986.

* Approximate allowable storage time exceeds 300 days.

Table 1. Allowable storage time for shelled corn with aeration: °Fahrenheit (F) & °Celsius (C)

Equilibrium Moisture Content, Corn, Yellow Dent (Wet Basis)														
Grain Temp (°F)	Grain Temp (°C)	Relative Humidity (%)												
		30	35	40	45	50	55	60	65	70	75	80	85	90
		Equilibrium Moisture Content (%)												
35	2	11.0	11.6	12.3	12.9	13.5	14.2	14.8	15.6	16.3	17.2	18.2	19.5	21.1
40	4	10.6	11.3	11.9	12.5	13.1	13.8	14.5	15.2	16.0	16.9	17.9	19.1	20.8
45	7	10.2	10.9	11.5	12.2	12.8	13.5	14.1	14.9	15.7	16.6	17.6	18.8	20.5
50	10	9.9	10.6	11.2	11.8	12.5	13.1	13.8	14.6	15.4	16.3	17.3	18.6	20.2
55	13	9.6	10.2	10.9	11.5	12.2	12.8	13.5	14.3	15.1	16.0	17.0	18.3	20.0
60	16	9.3	9.9	10.6	11.2	11.9	12.6	13.3	14.0	14.8	15.7	16.8	18.1	19.7
65	18	9.0	9.7	10.3	11.0	11.6	12.3	13.0	13.8	14.6	15.5	16.5	17.8	19.5
70	21	8.7	9.4	10.0	10.7	11.4	12.0	12.7	13.5	14.3	15.3	16.3	17.6	19.3
75	24	8.5	9.1	9.8	10.4	11.1	11.8	12.5	13.3	14.1	15.0	16.1	17.4	19.1
80	27	8.2	8.9	9.6	10.2	10.9	11.6	12.3	13.1	13.9	14.8	15.9	17.2	18.9
Iowa State University Extension Grain Management Team; Hurburgh, C., S. Shouse, G. Brennenman, K. Leibold, S. Johnson, M. Licht, & A. Robertson.														

Table 2. Equilibrium moisture content for corn.

Wet Holding Tank Air Flow Requirements					
Relative Humidity (%)				CFM/BU.	m^3/hr/MT
Corn	Soybeans	Wheat	Rice	Airflow	Airflow
14%	10 - 11%	12 - 13%	10%	1/10 - 1/8	8 - 10
15 - 17%	12 - 13%	14 - 15%	11 - 12%	1/7 - 1/5	11 - 15
18 - 20%	14% - Max	16 - 17%	13 - 14%	1/4 - 1/2	19 - 38

Table 3. Wet holding tank air flow requirements.

5.2. Grain Storage

5.2.1. Grain spoilage can occur due to improper storage and management. Most common problems are:

- Improper grain management.
- Grain moisture content is too high for the storage period.
- Grain deteriorating because it was held too long without adequate aeration prior to drying.
- Improper cooling of the grain after drying. The grain must be dry and cool before storing.
- Not using aeration to control grain temperature.
- Poor initial grain quality which includes, pockets of fines (broken kernels, weed seeds, and trash) restricting airflow and providing food for insects and mold.
- Improper insect control within the grain.
- Inadequate observation of the grain during storage. The grain must be checked on a periodic basis.

5.2.2. **Moisture Content of Grain Storage** - The length of time grain can be stored without aeration and the moisture content at which it is stored determine whether there will be significant deterioration. Short-term storage generally refers to winter storage. Long-term storage spans more seasons. Table 4 shows recommended maximum moisture contents for safe grain storage. The values shown in this table are for good quality, clean grain, and aerated storage. Reduce moisture content 1% for poor quality grain resulting from drought, frost, blight, harvest damage, etc. Contact local elevator or your local extension office for recommended moisture contents and storage times.

5.2.3. Grain should be dried to the moisture content required for the intended storage period. Aeration is used to control the grain temperature and to prevent grain loss. (See the Aeration section).

5.2.4. For best results in storing dried grain, an accurate moisture test is needed to determine if the grain is dry. An aeration system is necessary for controlling grain temperature. **Aeration is not drying.** A drying fan can be used for cooling if grain is stored in the bin in which it is dried. If grain is to be placed into a different bin, it should

Maximum Moisture Content of Grain Storage	
Grain Type & Storage Time	**Maximum Moisture Content for Safe Storage (%)**
Shelled Corn & Sorghum	
Sold as #2 grain by spring	15 1/2
Stored 6-12 months	14
Stored more than 1 year	13
Soybeans	
Sold by spring	14
Stored up to 1 year	12
Stored more than 1 year	11
Wheat, Oats, Barley	
Stored up to 6 months	14
Stored more than 6 months	13
Sunflower	
Stored up to 6 months	10
Stored more than 6 months	8
Flaxseed	
Stored up to 6 months	9
Stored more than 6 months	7
Edible Beans	
Stored up to 6 months	16
Stored more than 6 months	14
McKenzie , B. A., L. Van Fossen. Managing Dry Grain in Storage. Agricultural Engineers' Digest AED-20.	

Table 4. Maximum moisture contents for safe grain storage.

be equipped with an aeration system to control the grain temperature during storage. It is imperative that the grain be cooled during storage to control insects and reduce moisture migration. Moisture content of grain for safe storage depends upon the grain and length of time stored.

5.2.5. **Grain Temperature** - It is important to manage grain temperature to prevent spoilage. Some important points to keep in mind are:

- Moving air through grain can control the temperature.
- Aeration is used to keep the grain temperature equalized thus preventing convection currents within the grain and creating wet spots.
- Maintain the grain mass temperature to within 10 to 15°F (6 to 8°C) of the average outside air temperature.
- Make sure to keep grain temperatures at or below 60°F to limit insect activity.

5.2.6. **Insect and Mold Control** - Insects can already be in the bin before filling or enter later. A few special precautions should be taken to prevent or impede insects from entering the grain.

- Thoroughly clean the bin and surrounding area of grain, dust and debris prior to filling.
- Repair cracks, holes, and crevices where moisture and insects may enter.
- Clean and check aeration systems, which can create places for insects to live.
- Avoid filling the bins with a new crop where the old crop exists.
- Depending on the length of time for storage and the stored moisture content, treat the bin and grain appropriately. Please contact your local or state extension office for proper treatment requirements.
- Dry and cool grain as soon as possible to the appropriate storage moisture percent and temperature to reduce insect and mold growth. Temperatures below 50°F will limit insect growth.

5.2.7. **Grain Condition** - Grain is stored best if it is cool, dry, and clean. Insect and mold growth is dependent on both temperature and grain moisture content. Grain that has considerable foreign material or broken kernels will be more susceptible to mold and insects. Insects and mold grow better on broken grain. Make sure to do the following:

- The grain should be clean and without damage to reduce potential mold and insect growth. Otherwise grain that is severely cracked or damaged should have the moisture content 1 percentage point lower than clean, undamaged grain.
- Clean out all grain handling equipment such as combines, trucks, wagons, and augers.
- Adjust the combine settings to minimize grain damage and maximize clean-out of fines.
- Bin loading augers should be operated at full capacity to minimize grain damage.
- Make sure that the grain going into storage is clean.

5.2.8. **Checking Grain** - All stored grain needs to be checked on a regular basis. Check stored grain biweekly during critical fall and spring months when outside air temperatures are changing rapidly. Check at least every two weeks during the winter, but more often if there are problems. Search for small changes that are indicators of potential problems, such as crusting or condensation on bin roof. It may also be necessary to check moisture of grain with a moisture meter. Any increase in temperature indicates a problem, unless outdoor temperatures are warmer than the crop. Check and record temperatures at several points in bin. Testing weight of crop is another evaluation to ensure it is at its best quality.

5.3. Leveling Stored Grain

5.3.1. The best storage results are obtained when the grain is level in the bin. Peaked grain can make it difficult and unsafe for proper grain observation if entry into the bin is required. Uniform aeration is harder to achieve with a peak grain pile. Also, leveling grain can help in the control of grain fines. Grain fines can be a problem especially when they concentrate in pockets. Fines, or broken kernels, are more susceptible to spoilage. Pockets of fines can also impede air flow which develop into hot spots. Leveling grain can be done with one of two methods:

- Use of a grain spreader.
- Withdrawing grain from center after filling. This is known as filling and coring the bin.

5.3.2. The use of a spreader creates a level surface that is safer and easier for entry into the bin for observation. It also distributes grain fines and thus minimizes any concentration of grain fines.

5.3.3. Coring the bin is done by unloading grain through the center sump at regular intervals while the bin is being filled. The peak is pulled down after several feet of new grain is added (see Figure 31). Coring during the initial filling will remove a major portion of the fines and foreign material. Another benefit of filling and coring the bin is that it will loosely distribute the grain and thus allow for better aeration. If no inverted cone is created during withdraw, bridging of grain has taken place and a very unsafe condition has been created. No one should enter bin until the situation has been safely corrected.

5.4. Moisture Migration

5.4.1. Crops are normally placed in storage at temperatures much warmer than winter temperatures. Since crops are good insulators, grain in the center of the bin will be the same temperature at harvest even after the outside temperatures have dropped well below freezing. This temperature differential causes moisture migration.

5.4.2. When warmer fall outside temperatures change to cool winter temperatures, air near the bin wall cools and sinks to bottom of bin. As air moves toward the floor and center of the bin it warms up and rises through the center mass of the grain. This movement of air is called convection currents. The warm air picks up moisture as it rises up through the grain. When the grain nears the surface, it cools the warm air and thus moisture in the air condenses. Cool air cannot hold as much moisture as warm air. As this circulation continues, moisture begins to accumulate near top center of the bin (see Figure 32).

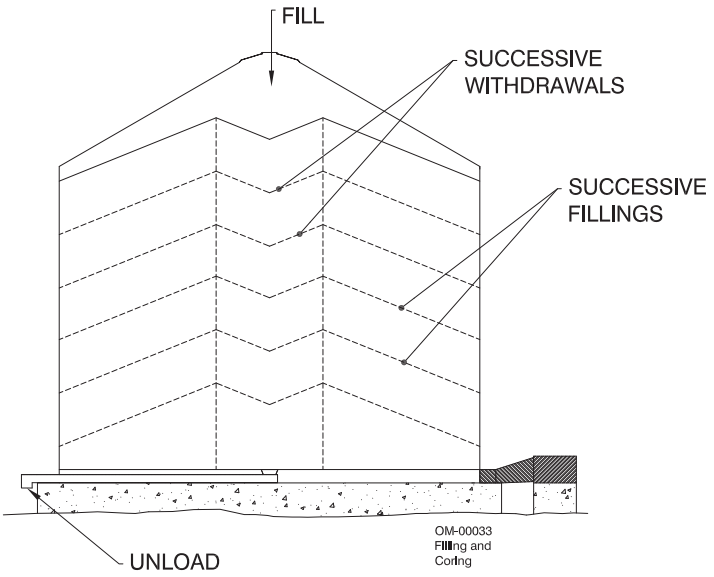


Figure 31. Filling and corning.

Crusting, wet, slimy grain, ice or frost accumulation is an indication of moisture accumulation and mold growth. An aeration system is important because it cools grain uniformly, limiting moisture migration.

5.4.3. In the spring and summer months when outside air gets warmer, moisture migration can occur the opposite way and moisture will accumulate at the bottom of bin.

5.5. Aeration

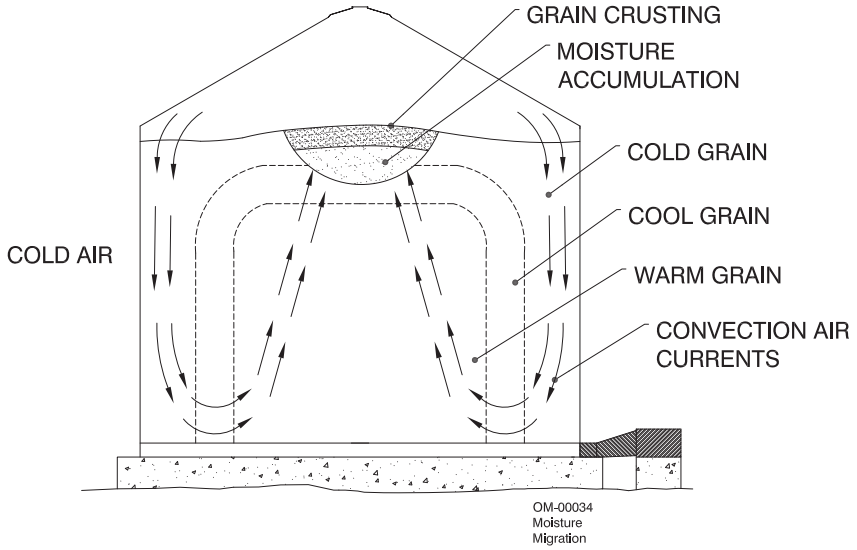


Figure 32. Moisture migration.

5.5.1. The objective of aeration is to get airflow through the grain to maintain uniform temperature and to prevent hot spots that accelerate spoilage. Aeration is also used to cool the grain after drying. Aeration is used to cool the grain when transitioning from fall to winter. Then it is aerated to warm the grain when transitioning from winter to spring and summer. Be sure airflow rates for aeration (storage) are 1/20 to 1/5 CFM/Bu., usually 1/10 CFM/Bu. (4 to 15 m^3/hr/MT, usually 8 m^3/hr/MT).

5.5.2. **Cooling Grain for Winter Storage** - Grain should be kept near the average outdoor temperatures during the fall. Modern grain management uses airflow to control the grain temperature. Increasing the airflow rate reduces the time needed for cooling or warming but also increases power requirements. Begin aeration to reduce grain temperature when the average outdoor temperature is about 10° to 15° F (6° to 8° C) lower than grain temperature. You can estimate when a cooling or warming cycle has passed through the crop by measuring the temperature. Repeat this cycle as often as necessary, checking temperature at several locations, until grain has cooled to 35° to 45° F (2° to 7°C).

Approximate Times for Grain Cooling or Warming Cycle				
Air Flow Rate		Fall Cooling	Winter Cooling	Spring Cooling
cfm/bu.	m^3/hr/mt	Hours	Hours	Hours
1/20	4	300	400	240
1/10	8	150	200	120
1/5	15	75	100	60
1/4	19	60	80	48
1/3	25	45	61	36
1/2	38	30	40	24
3/4	57	20	27	16
1	76	15	20	12
1 1/4	95	12	16	10
1 1/2	114	10	13	8

Table 5. Length of time to change grain temperature.

5.5.3. For positive pressure systems, check temperature at top of grain. For negative pressure systems, check temperature coming out of fan. Be sure to continue each aeration cycle until cooling front has moved completely through grain. This minimizes the chance for a moisture front within the grain mass to cause spoilage. Table 5 shows length of time required to change grain temperature. To be sure the cooling front has passed through grain, check grain and air temperature.

5.5.4. DO NOT FREEZE GRAIN due to problems it can create, particularly during warming and in larger bins. Condensation during aeration can be a problem in grain cooled below freezing. It may be difficult to warm grain in spring without condensation immediately freezing into ice. Frozen chunks block aeration warming cycles and grain unloading. Condensation also re-wets grain and can cause sudden bin failure and collapse due to expansion of kernels.

5.5.5. **Managing Grain in Spring and Summer** - Start fan when average outdoor temperature is 10° to 15° F (6° to 8° C) above grain temperature. Continuously run the fan until the warming front has moved through the grain. Stopping the warming front before a cycle is completed encourages condensation of moisture and spoilage. As outside temperatures continue to rise, repeat this cycle as often as needed until average grain temperature is 50° to 60° F (10° to 16° C). Maintain the grain temperature within 10° to 15° F (5° to 8° C) of the average monthly temp. Do not warm grain to summer temperatures.

5.6. References

5.6.1. Grain management information in this section of the manual are general guidelines and are from the following listed sources. Consult your local extension offices or consulting engineer for information specific to your facility.

- Grain Drying, Handling and Storage Handbook, MWPS-13.
- Managing Dry Grain in Storage, AED-20.
- Ladders, Cages, Walkways and Stairs, ASABE S412.1, March 1990 (R2008).
- University Extension Offices
  - North Dakota State University
  - Purdue University
  - Iowa State University
  - University of Nebraska - Lincoln

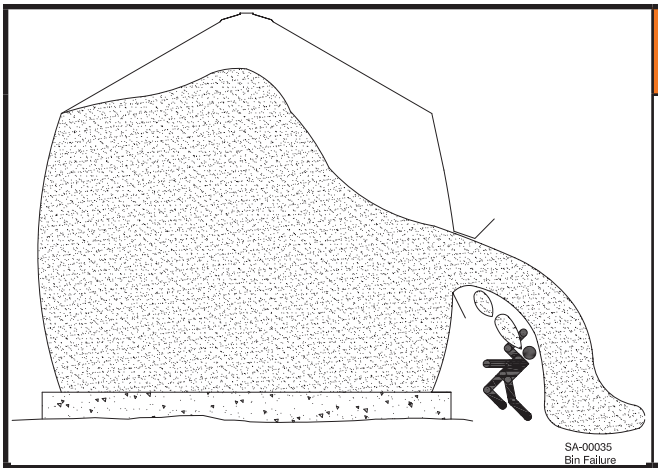
Observation	Probable Cause	Recommended Action
Musty or spoiled grain odor.	Heating moisture accumulation in one spot.	Run the fan. Smell the exhaust while in the bin or in front of the exhaust fan. Run the fan to cool any hot spots. If damage is severe, remove the grain.
Hard layer or core below grain surface.	High moisture or spoiled, caked grain mass.	Run the aeration or drying fan. Check to see if caked or compacted mass blocks airflow. Cool and dry if airflow is adequate, otherwise unload to remove all spoiled grain.
Warm grain below top surface.	Moisture content too high.	Run the fan regardless of weather conditions until the exhaust air temperature equals the desired grain temperature.
Surface grain wet or slimy. Grain is sticking or frozen together.	Early signs of moisture migration, often noticeable only 1-2 weeks after binning.	Run aeration fan. Cool grain until exhaust temperature equals desired grain temperature or outside air temperature.
Hard surface crust, caked and blocking airflow. Possibly strong enough to support a man.	Severe moisture migration and condensation in the top surface.	Remove the spoiled layer. Wear a dust mask to filter mold spores. Run the fan to cool grain after spoilage is removed. Sample grain with probe to determine condition throughout center mass below the crust. Consider marketing grain to arrest further spoilage.
Under-roof condensation dripping onto surface.	Warm grain in cold weather, severe convection circulation and moisture migration.	Aerate until exhaust air temperature equals outdoor air temperature at beginning of aeration cycle.
Wet or spoiled spots on grain surface outside center point.	Condensate drip from bolt ends or under roof fixture that funnels condensate flow; possible roof leak.	Check grain for heating. Check roof under surface at night. Check for caulking around roof inlets and joints.
Wet, spoiled spot directly under fill cap.	Leaking roof cap or condensed water from gravity spout.	Check bin cap seal and hold down. Block or disconnect gravity spout so air from bin and grain cannot flow up tube. Marginal solution: hang bucket under spout inlet and check bucket for water accumulation.
No air flow through grain with aeration fan running.	Moldy, caked grain mass blocking flow; possible moldy grain layer immediately above aeration duct or perforated floor on suction system.	Try to determine location and scope of spoilage. Unload storage and market or re-bin good grain.
White dust visible whenever grain is stirred.	Mold on grain but not sufficient spoilage to seal top surface.	Wear dust mask in working grain. Evaluate grain condition throughout bin where possible. Observe caution in continued storage because grain condition has deteriorated to some degree.
Cooling time required much longer than usual.	Increased fines in grain resisting and reducing airflow; increased fines can cause airflow resistance to increase as much as 2-4 times over that of clean grain.	Run the fan longer time. Operate fan until grain and exhaust air temperature readings indicate grain is at desired temperature, regardless of fan time required.
Exhaust air temperatures in center of bin surface warmer than those away from center.	Fine material accumulation in storage center resisting airflow; airflow through center mass grossly reduced compared to relatively clean grain around outside of storage.	Run the fan sufficient time to cool the center irrespective of the outside grain temperatures. Draw down the bin center to remove fines and decrease the grain depth for easier air passage in the center core.
Unknown grain conditions in the bin center	Too deep to probe; bin too full to access; no temperature sensing cables installed.	Withdraw some grain from all bins to feed or market. Observe (look, feel, smell) first grain to flow with each withdrawal, since it was in the center core. Withdraw any storage filled above level full, as soon as possible following harvest, to reduce moisture migration tendencies and permit access for observation and sampling.
McKenzie, B. A., L. Van Fossen, 1995, “Managing Dry Grain In Storage”, Agricultural Engineers’ Digest-20.		

Table 6. Troubleshooting issues.

7. Maintenance

7.1. General

7.1.1. Proper grain bin and equipment maintenance before and during harvest season will help ensure that good quality grain will be stored and preserved. The grain bin will provide many years of extended service if properly maintained. Information listed below outlines maintenance inspections that should be performed on a regular basis. Use this list as a maintenance checklist.



WARNING

Damage from lack of maintenance may cause sudden structural failure and collapse, which may result in personal injury or death. Frequently monitor and inspect the bin and foundation for any deflections, cracks or deviations that may occur. Follow operation and maintenance instructions described in this manual.

7.2. Roof, Stairs, and Vents

- **NOTE: Clean debris off of bin roof, peak ring, roof vents, and stairs at the end of each harvest season.** Dust and debris can cause damage to roof as well as make steps/rungs slippery and unsafe to walk on. Not cleaning debris above roof vents can cause white and brown rust to develop on galvanized metal.
- If an excessive amount of heavy snow accumulates or builds up unevenly on one side of roof, it must be removed immediately.
- **Important:** Inspect the grain bin roof and sidewall for leaks, loose or sheared bolts, and rust or other corrosion. Caulk any cracks, replace and tighten all missing bolts and nuts with the correct type and size, and remove rust or corrosion with wire brush and paint over the area. Contact Behlen Mfg. Co. if there is a problem.
- Ensure proper function of attachments to all grain bin openings such as roof doors and roof caps. Be sure all latches and hold-down clips are used as intended. Also, make certain the roof cap has a tight weather seal and is in the correct position if an overhead conveyor is mounted. Spouts require the roof cap to be permanently fixed.
- Tighten any loose bolts used to attach the roof ladder or stairs to the roof ribs and, if necessary, install handrails to increase worker safety and prevent accidents. Also, be certain the roof guard rail is secure. Because of workers being at extensive heights, it is important that all roof components be rigid.
- Whenever on the roof, inspect all roof panels, supporting ribs, stairs, steps, vents, and especially all connections to be certain accidents do not occur. Roof vents should be checked for blockage caused by dirt, dust, debris, frost, ice, bird nests, etc. Clean any debris to allow free airflow and to prevent damage to roof.

7.3. Ladders, Catwalks, and Supports

- Be certain that access ladders, catwalks and platforms are complete and securely fastened to the grain bin.
- Catwalks are often supported by steel structures bolted to the grain bin sidewall stiffeners. Make sure to perform frequent inspection on all connections between catwalks and supports. Bent braces, loose bolts and sidewall damage are all extreme situations that could put someone's safety in serious danger.
- While climbing a ladder, check for any worn-out or loose rungs, loose or missing bolts, and dangerous jagged edges protruding from the ladder or safety cage. Determine the cause and fix or replace the item. If a sheared bolt is discovered, contact Behlen Mfg. Co. It may be an indication of a more serious problem.

7.4. Sidewall Sheets, Stiffeners and Doors

- Periodically inspect the exterior of the grain bin. Check for sheared or missing bolts, buckled or torn sheets, sidewall bulges, or any unusual changes in bin's appearance. Pay particular attention to bolted joints, noting any waviness along the edges, elongated bolt

holes, or cracks, all of which are signs of over-stress. If a problem is detected, contact Behlen Mfg. Co.

- Ensure each stiffener base is correctly anchored to foundation. If the base plate is not bearing uniformly on the concrete foundation, buckling of the stiffener somewhere above the base could occur.
- Visually inspect stiffeners and splices to ensure there are no gaps. Improperly connected stiffeners will cause sidewall and stiffener buckling. Be certain the stiffener base is level on the concrete pad, all bolts and nuts are tight, and stiffeners are supported through an aeration tunnel.
- Before filling, be sure doors are shut and seal against the frame. Remember to lock the inner doors tight against the frame to ensure no structural damage occurs or leakage of water into the grain.

7.5. Foundations and Tunnels

- Inspect the grain bin foundations for structural problems. Uneven foundation settlement can cause gaps at the bottom of the bin, resulting in spilled grain, entry points for water, insects, rodents, and allow forced air to escape, reducing efficiency and increasing costs.
- **Inspect concrete routinely for exposed rebar, unusual cracking, or spalling of concrete.**
- **Be sure all anchor bolts are tightened and undamaged.** Cracks that develop around anchor bolts result in the grain bin being susceptible to wind damage. Be certain the base of the bin is uniformly resting on the foundation and sealant is intact. If gaps occur, caulk between the bottom of the bin and the foundation.
- Sidewall and tunnel failure may occur if the tunnel is not correctly constructed or supported at the tunnel outlet on the stem wall. If cracks or breaks occur in the stem wall, contact the structural engineer immediately for proper instructions and measures to correct damage.
- Inspect the tunnel roofs on a regular basis for cement spalling, cracks, and deflections. Inform the concrete contractor of appearance of cracks or impending failure of the tunnel roofs. Removable conveyor cover plates must be fitted, flashed, and sealed to prevent accidental leakage into the conveyors, which could result in eccentric discharge of grain from bin.

7.6. Aeration Systems

- Periodically remove fan transitions and check beneath the floor for condition of the supports, presence of pests, dust buildup, and foreign material. Clean and repair if required.
- Check fans, heaters, transitions, and ducts for corrosion. Remove any accumulated dust and dirt that will reduce operating efficiency. Be sure all wire and pipe connections are tight and in place.
- Inspect aeration system by looking for grain leaks and grain remaining in the trenches. Find the source and remove any grain in the way. Caulk any holes or cracks to prevent insects or water from getting in and grain from getting out.
- Grease motor bearings (if required) per the manufacturer's recommendations. Operate fans per the manufacturer's operations manual.

7.7. Electrical

- Wiring for fans and other electrical components should be inspected for corrosion and cracked, frayed, or broken insulation. Exposed wiring should be run through waterproof, dust-tight conduit. Make sure all connections are secure.
- Check control boxes for rodent damage. If found have a licensed electrician, clean and repair or replace broken wiring, relays, and other components and seal over openings that allowed rodent entry.

7.8. Site Maintenance

- Remove any spilled grain from the grain bin site. Mow around the bins to reduce likelihood of insect or rodent infestation and to make certain water drains away from the bin foundations. Items or debris left near the bin site may interfere with safe, unobstructed movement around bin.
- Treat the outside of the grain bin at the foundation and around doors, ducts, and fans with insecticide if an insect problem arises.
- Thoroughly clean all bins by removing all old grain. Do not put new grain on top of old. This will help prevent mold and insect infestation of the new grain. Remove all traces of old grain from combines, truck beds, grain carts, augers, or any other equipment used for harvesting.
- Remove all rust and cover with rust-inhibiting primer or paint. It is better to take care of problems in the early stages of corrosion.

NOTICE

If for any reason you find buckled sheets, sidewall bulges, or any changes in the grain bin's appearance, please contact Behlen Mfg. Co. engineering to determine if there is a problem and to find a solution.

7.9. Replacement Parts

7.9.1. Modifications and repairs are often needed due to weather, deterioration, usage, and mishaps. The key to constantly having your grain bin in first-rate condition is to frequently review the maintenance checklist on the pages in this section and repair any problems promptly.

7.9.2. Wiring for fans and other electrical components should be inspected for corrosion, cracks, and frayed insulation. Exposed wiring should be routed through a waterproof, dust-tight conduit. Avoid kinks in conduit and make sure all connections are secure. Procure the services of a licensed electrician if any electrical components or wiring requires repair or replacement.

7.9.3. To replace any deteriorated parts, contact your local dealer/distributor. **Note: Do not substitute materials for replacement parts.** Your grain bin is assembled with certain materials at specific thicknesses. Do not replace parts without contacting your local dealer/distributor.

7.9.4. Prior to equipment use, please check that all decals are in place according to this manual and in good, legible condition. Safety decals are available for replacement at no charge for Behlen grain storage bins. Refer to Safety Section of this manual and please specify decal number.

In Case of an Emergency

Have emergency telephone numbers near telephones and written directions to your location. Provide an emergency action plan as specified by OSHA 1910.38 and train employees on this safety plan. Have posted floor plans or workplace maps that clearly show emergency escape routes assignments, location of exits, designated safe areas, and emergency equipment locations such as fire extinguishers, shut-off valves, disconnects, etc.

EMERGENCY CONTACTS:

DOCTOR:_____

HOSPITAL:_____

AMBULANCE:_____

FIRE:_____

POISON:_____

HAZARDOUS MATERIALS:_____

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