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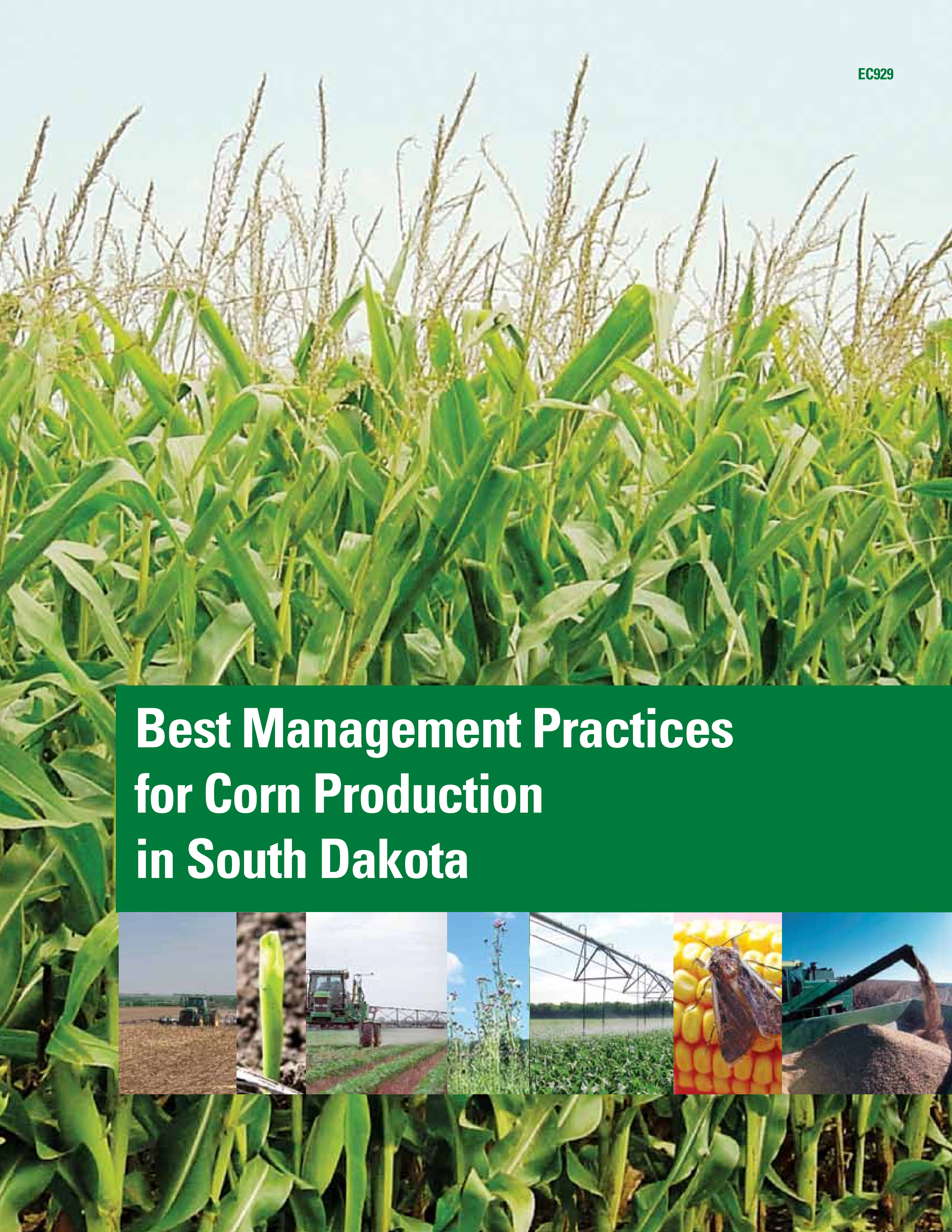


Best Management Practices for Corn Production in South Dakota

CHAPTER 12
Corn Drying and Storage

The goal for a corn drying and storage system is to maintain grain quality without impeding harvesting or shipping. This chapter describes the factors that influence grain quality, proper handling techniques, drying procedures, storage management, and safety precautions.

Grain Quality

Corn grain quality at harvest is influenced by a variety of weather conditions, harvest adjustments, and handling procedures. High-quality corn has the following characteristics:

Few fines and foreign materials.
- Clean corn dries and stores better. To remove fines and foreign material, consider installing a grain cleaner. A bypass mechanism is recommended when cleaning is not necessary.

Little physical damage and few stress cracks.
- Test incoming grain for broken corn and foreign material to evaluate harvesting and variety performance.

Very little mold and insect damage.
- Inspect stored grain periodically to determine if insect control is necessary.

Grain quality will not improve with storage, drying, or handling. Minimizing corn grain damage during storage requires that the storage system have good drying, cooling, and handling characteristics.

Drying Damage

Stress cracks are fractures inside the kernel that are not expressed on the outer seed coat. These cracks increase kernel breakage during handling and reduce milling quality. Drying techniques influence the occurrence of kernel stress cracks. Kernel stress cracks develop when corn is rapidly dried at high temperatures through the critical moisture range of 19% to 14% and is then quickly cooled. Slow drying and delayed cooling reduces cracking.

Drying Temperatures

Comparatively lower drying temperatures maintain higher grain quality (i.e., test weight, color, and brittleness). Initially, if the corn has a high moisture content, a lower drying temperature is needed to maintain grain quality. If grain quality is poor at harvest, low drying temperature becomes even more critical to prevent further reduction in quality. If cooled immediately, corn can be dried in high-speed automatic “batch” or “continuous-flow” dryers at 200 to 220°F. Corn can be dried at temperatures up to 240 to 250°F if cooling is delayed. Heated “in-bin” dryers, with or without stirrators, should be operated between 110 and 140°F. If corn drying depths exceed 4 feet without stirration, to prevent over-drying the drying air temperature should be limited to 10°F above ambient air temperature.

Handling Damage

Corn kernel damage can be minimized by properly sizing and operating handling equipment. Reducing kernel drop heights and travel velocity reduces the potential for breakage. Increased kernel breakage results from the following:

- improperly installed or operated handling equipment
- corn kernel impact at high velocities
- kernel stress cracks developed during drying and/or cooling
- very dry or cold kernels

To prevent grain damage, augers should be operated at the manufacturer-rated capacity. If incoming flow rates are variable, using bearing-supported augers can prevent kernel damage. Kernel damage also can be reduced by installing surge bins over the hopper (surge bins keep the auger full when incoming flow rates are variable).

Bucket elevators cause little kernel damage if drop heights are minimal. When drop height exceeds 40 feet, kernel damage potential increases. Installing grain decelerators every 40 feet in the down spout can reduce kernel damage.

Storage Damage

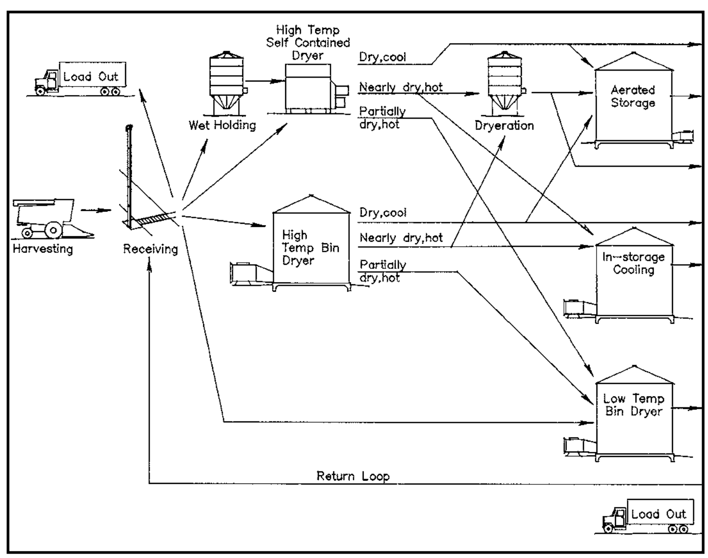
Mold and insects cause most of the damage that occurs during storage. Corn that is improperly stored or dried or is damaged is susceptible to both molds and insects. Aeration in storage facilities controls grain temperature and reduces the chance for spoilage. Pockets of fines (broken kernels, weed seeds, trash) can cause spoilage, as they restrict airflow and provide food for insects and mold. Spoilage can be reduced by removing fines with a grain cleaner and by adjusting the bin grain spreader to reduce the concentration of fines.

Grain Handling

A well-organized grain handling system reduces time and stress during a busy season and improves efficiency. Handling systems include conveyors, hoppers, pits, surge bins, spreaders, sweep augers, and cleaners. The system is designed to receive grain, move the grain from one component to another, and load grain for transportation (fig. 12.1). Factors for consideration when planning a corn handling system are as follows:

- **Performance** – completing the job in the time allowed without a loss of quality.
- **Capacity** – matching the handling system to the farm needs.
- **Convenience** – ease of handling with the labor available.
- **Cost** – balancing equipment costs with farm need and revenue.

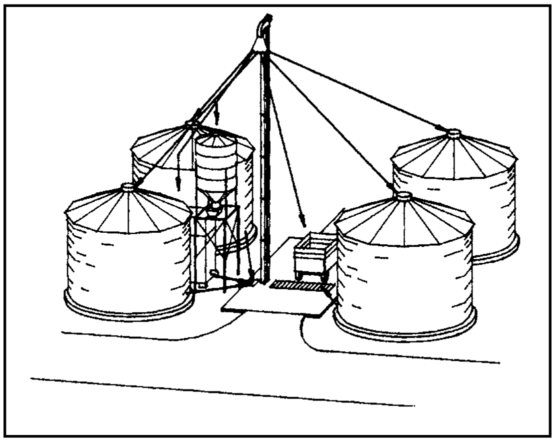
Figure 12.1. Grain center facilities and conveying processes



(Courtesy of Cloud et al. 1997)

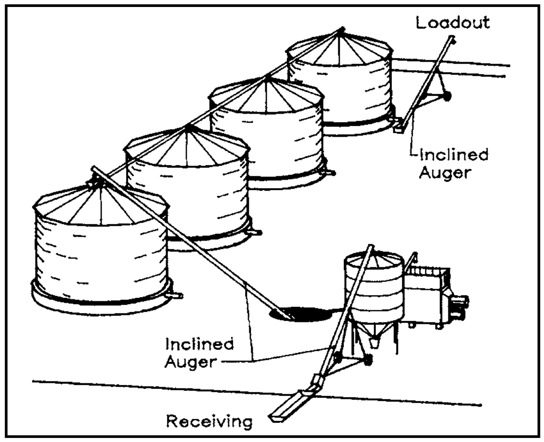
The receiving and load-out areas are often the hubs of larger handling centers, with bucket elevators used for conveyance (fig. 12.2). The handling center should be planned so that the grain can go from the elevator to any component (e.g., wet holding, dryer, storage). This

Figure 12.2. Bucket elevator system



(Courtesy of Cloud et al. 1997)

Figure 12.3. Inclined conveyor system

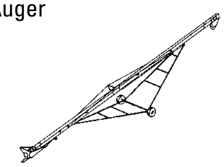
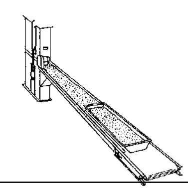
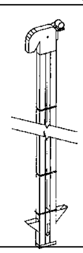
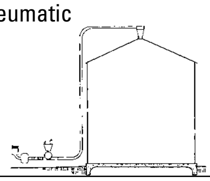


(Courtesy of Cloud et al. 1997)

type of system is convenient because it can be easily automated and requires no setup time. These systems are also able to handle both low-capacity conveying and high-capacity needs. Good planning allows the system to grow gradually from a low-investment, low-capacity system to a high-capacity system.

In smaller centers, the system may not require as much convenience and conveyance; therefore, the cost of the handling system can be reduced. Figure 12.3 depicts an auger conveying system where the grain is not returned to the central hub for load out. Table 12.1 lists and categorizes some of the more common conveyors used to move grain.

Table 12.1. Comparison of selected grain conveyors

Type of Conveyor	Horsepower Requirement	Advantages	Disadvantages
Auger 	Low to medium with dry grain; medium to high with wet grain	Simple, widely available in many sizes. Low cost. Available for horizontal, inclined, or vertical applications. Portable, wheeled, or fixed.	High torque and power required for wet grain. Medium-to-heavy wear. Noisy – if not bearing-supported. High kernel damage – if not operated at rated capacity.
Belt 	Low	Good for long distances. Low power requirement. Quiet Least handling damage. Capacity only affected by grain weight. Self-cleaning.	Limited in angle of elevation. Expensive. Belt maintenance.
Bucket 	Low	Efficient, compact. Low maintenance. Quiet High capacity for vertical lift. Reliable and adaptable to automation. Easily cleaned.	Difficult to erect and change capacity. Expensive. Grain damage high for large drop heights. Elevator head service is difficult.
Pneumatic 	High	Flexible installation. Easily cleaned. Convenient grain delivery to many locations.	High power requirement. Creates dust, usually requires separation equipment.

Drying

Wet corn either must be used or must be dried for storage. A "rule of thumb" is that corn should not be harvested until the moisture content is less than 30%. If storage is planned for 12 months or less, corn should be dried to 14% moisture content; if storage is planned for longer than 12 months, 13% moisture content is the target. The relationship between storage time, grain moisture, and storage temperature is shown in Table 12.2. At low temperatures (30 to 35°F), corn with moisture contents of 14 or 15% can be safely stored for extended periods of time. However, the risk of spoilage increases with temperature.

Table 12.2. Allowable grain storage time (in days, as influenced by grain moisture percentage and storage temperature [modified from Pohl and Durland 2002])

Temperature degrees °F	Grain moisture percentage (%)										
	14	15	16	17	18	20	22	24	26	28	30
30			847	503	323	160	95	64	47	37	31
35			634	377	242	120	71	48	35	28	23
40		879	474	282	181	90	53	36	26	21	17
50		492	265	158	101	50	30	20	15	12	10
60	576	275	149	88	57	28	17	11	8	6	5

A complete drying system includes grain-receiving equipment, a wet-holding tank, a dryer, grain-cooling equipment, and conveyance of the corn to the storage bin. A well-designed drying system should

- be safe and convenient,
- not slow harvesting and have adequate capacity,
- provide a space where wet corn can be stored prior to drying,
- have an appropriate drying and ventilation system,
- result in a minimum loss of quality,
- provide the opportunity for future expansion.

There are numerous types of grain-drying systems, but they can be characterized into 5 general categories (Table 12.3). The characteristics of each drying system are as follows:

Low-temperature and natural-air bin dryers

- Grain is dried slowly in these systems. These systems work best in low-temperature and low-humidity environments. With low-temperature dryers, air is heated to 10°F above ambient air temperature (in natural drying systems, the air is not heated). In low-temperature systems, the corn is placed in a bin that has a perforated floor, a high capacity fan, and a spreader. Airflow for southeast South Dakota should be 1.25 cfm/bu (cubic feet per minute/per bushel), and for the balance of South Dakota airflow should be at least 1 cfm/bu. As reported by Hansen (2005), natural air-drying systems take advantage of the temperature, moisture, and storage-length relationships shown in Table 12.3. Natural air-drying systems can be used to reduce energy inputs. To prevent spoilage, careful management (which may involve frequent climbs to the top of the bin to inspect the grain) is needed. These systems can be used to store grain for relatively long periods of time at 15% moisture. Details about natural-drying systems are available in Hansen (2005) and in Wilcke and Morey (1995).

High-temperature bin dryers

- In high-temperature bin dryers, a layer of corn (usually not more than 9-feet deep) is placed on the floor and the air is heated to between 120 and 180°F. Corn dries as heated air moves through the layer of grain. If temperatures are near the high end of the range, a delayed cooling cycle should be used to reduce kernel brittleness and stress cracks.

Continuous-flow bin dryers

- Continuous-flow bin dryers typically are bins with a perforated drying floor, a fan, a heater, a grain spreader, unloading equipment, and an auger for the transfer of grain to storage. Grain flow to both storage and cooling bins is usually automatically controlled. Separate wet holding bins can assure optimum drying depths.

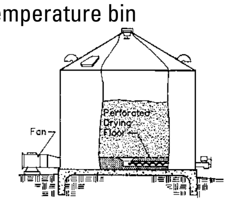
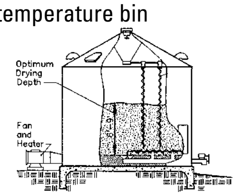
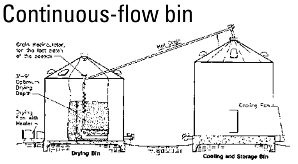
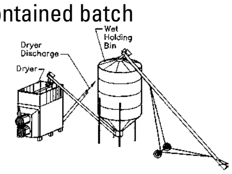
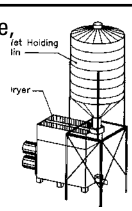
High-temperature, self-contained batch systems

- High-temperature, self-contained batch systems have all the drying equipment (filling, unloading, and controls) built into the dryer. These dryers are movable, but fuel, electricity, and corn-handling equipment are required at each site. Batch drying systems require more time compared to continuous-flow systems, as drying does not occur during filling and unloading.

High-temperature, self-contained continuous-flow dryers

- High-temperature, self-contained continuous-flow dryers are loaded and unloaded either continuously or in frequent intermittent cycles. Loading and unloading conveyors must be sized for maximum grain-drying capacity.

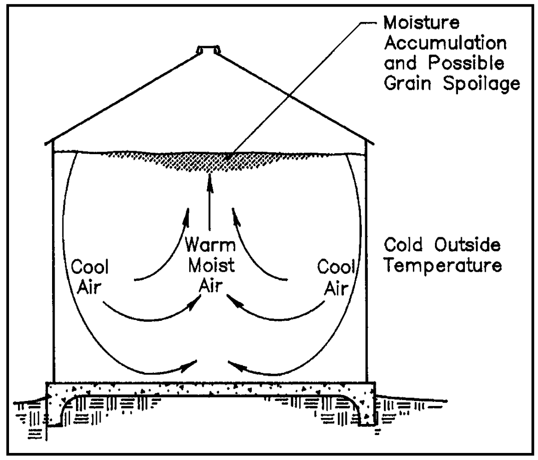
Table 12.3. Comparison of selected grain-drying systems

Type of Drying System	Relative Cost	Advantages	Disadvantages
Low-temperature bin 	Low	Very little corn handling required. Fast harvesting (i.e., not waiting for dryer). Same system used for both drying and storage.	Maximum filling moisture content is 22%. High humidity and low temperatures reduce drying rate. Works best in low-humidity regions. Requires careful management.
High-temperature bin 	Low to medium	Dryer bins can be used for storage after last drying batch. Mixing wetter and drier corn in conveying auger after drying improves storage.	Drying and storage are in separate bins. If dryer bin does not have stirring system, limit drying depth to 2.5–4 ft. More labor than other high-temperature drying.
Continuous-flow bin 	Medium	Dryer bins can be used for storage after last drying batch. Mixing wetter and drier corn in conveying auger after drying improves storage.	Drying and storage are in separate bins. Drying bin must be completely emptied every few days to prevent fines from accumulating.
High-temperature, self-contained batch 	Medium to high	Cooling cycle is built into dryer, or it can be programmed to cool in bin. System can be automatically controlled.	Drying cycle time is longer than continuous flow. Requires a separate wet-corn holding bin.
High-temperature, self-contained continuous-flow 	High	Low-capacity conveyors can be used to move dried corn to cooling or storage bins. Recovering some discharge air from lower part of dryer can save energy.	Requires a separate wet-corn holding bin.

Storage

Storage protocols should be used to maintain grain quality. During storage, grain quality does not improve and can only decrease if proper precautions are not taken. Grain temperature is the primary factor influencing spoilage. Lower storage temperatures decrease biological and insect activity, thereby increasing safe-storage periods. Whether the storage is short- or long-term, the proper selection of construction materials, sizing, and location are essential. Corn quality is generally easier to manage in small storage containers than in large storage containers. As a general rule, never have more than 1/2 of the total annual grain production in a single storage facility. A mixture of storage sizes provides the flexibility to meet changing needs. To minimize storage costs and maximize management flexibility and production and/or marketing options, the storage capacity should be large enough to meet your needs at a reasonable cost per bushel.

Figure 12.4. Pattern of moisture migration in stored grain



(Courtesy of Cloud et al. 1997)

Managing grain in storage is important to maintain grain quality after it is harvested. To maintain quality, moisture and insect activity must be controlled. Factors that can cause corn to lose quality during storage include the following:

- initial grain quality
- grain moisture content
- grain temperature
- amount and distribution of fines and foreign material
- the presence of insects

Spoilage can occur in isolated areas of the bin ("pockets") where kernel moisture is high. Pockets of high kernel moisture can result from moisture migration. For example, as outside temperatures drop during late fall and winter, corn in a bin does not cool uniformly. Corn near the bin wall cools more rapidly, causing a convection air current (fig. 12.4); the air then rises through the warm center, where air moisture content is increased. As the warm air reaches the corn surface, moisture condenses and accumulates. Moisture migration can result in spoilage and can be minimized by maintaining an even grain temperature in the bin.

An aeration system is essential for preventing temperature variation. In order to control temperature (and also reduce insect activity), an aeration system moves air through the stored corn. In South Dakota, for overwinter storage, stored corn should be uniformly cooled to below 35°F; for storage during the spring, summer, and fall, corn should and warmed to between 50 and 60°F. An airflow rate of 1 cfm/bu is adequate for most corn aeration in South Dakota. Storage systems should be routinely monitored to prevent loss from spoilage and insect damage.

Broken corn kernels and fines can increase spoilage by changing airflow patterns. Air currents from aeration fans tend to go around pockets of fines, resulting in slower cooling. Pockets of fines often develop into hot spots that result in spoiled grain. To minimize problems, 1) clean the corn with a screen cleaner before putting it in the bin and 2) use a spreader during bin loading to evenly spread the remaining fines.

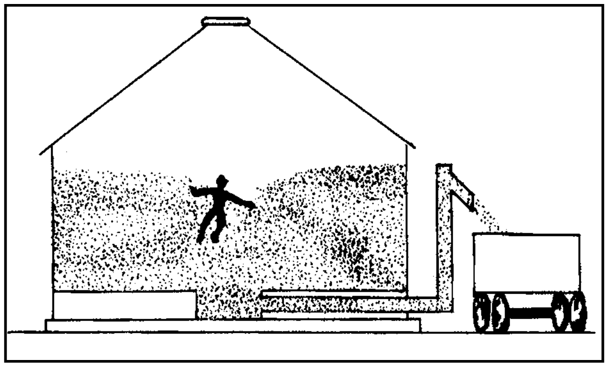
In round bins without a distributor, dried corn peaks at an angle of between 18 and 20°. Peaking allows for more bushels to be stored in the bin, but it can cause moisture-migration problems. Peaks can be reduced or removed by withdrawing a small amount of grain immediately after loading the bin.

Safety

Absolutely forbid entry into a bin or gravity-flow trailer when grain is flowing. Suffocation is a major cause of accidental death when handling corn (fig. 12.5). Always be aware of the following safety rules when working with flowing grain:

- Always lock access doors to grain storage structures.
- Lock out power to all types of grain-handling equipment.
- Always use the "buddy system" (notifying a second person [who is at your location] where you are) when unloading or loading grain.
- Never permit children to ride in grain wagons or enter grain storage areas.
- Always know where ALL family members are (especially children) at all times when grain is loaded, unloaded, moved, or otherwise handled.
- Do not enter grain bins that are being loaded or unloaded. Flowing grain can trap and suffocate you in seconds.
- Never allow children to play in grain storage equipment, whether the equipment is empty or full.
- Maintain, repair, or replace broken safety shields on open chains, belts, and power-take-off (PTO) shafts.

Figure 12.5. Flowing corn can trap you in seconds



(Courtesy of Cloud et al. 1997)

Breathing mold spores in stored corn can cause illness and may lead to chronic health problems. When working in dusty or moldy corn, wear a respirator that filters fine dust. Disposable masks or respirators with replaceable cartridges designed to filter dust ensure protection for grain handlers. Change the mask or cartridge frequently for the greatest protection. Filter masks may provide adequate protection from common agricultural molds, dusts, and chaffs; however, they will not protect the wearer from gases during and after grain bin fumigation.

Absolutely forbid entry into a grain bin during or after fumigation; wait either until the bin has been cleared or until the reentry interval stated on the product label has been satisfied. Fumigation management plans are required for anyone fumigating stored grain. More information is available from the South Dakota Department of Agriculture, Office of Agronomy Services, or online at http://www.state.sd.us/doa/das/fum_mgmt_plan.pdf.

Maintain proper and effective shields and guards on such hazardous equipment as moving belts, roller chains, pulleys, sprockets, gears, and shafts. Wear work clothing with no loose ends or strings that may catch on machinery. Make sure everyone who operates the equipment has the appropriate training and is physically, mentally, and emotionally able to operate the equipment safely.

Additional Information and References

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