Above Average Grain Storage Management

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Above average managers:

1. Know their (system) limitations
2. Minimize grain damage
3. Understand AST (allowable storage time)
4. Use wet holding effectively
5. Understand their drying system
6. Core their bins
7. Control grain temperature
8. Monitor grain in storage
9. Actively manage for safety
10. Have a backup plan

Know your (system) limitations

Can I dry grain without heat?

Most years, probably successful up to 22% moisture.

(based on Albany fall weather similar to Iowa)

Do I have enough airflow for drying or cooling grain?

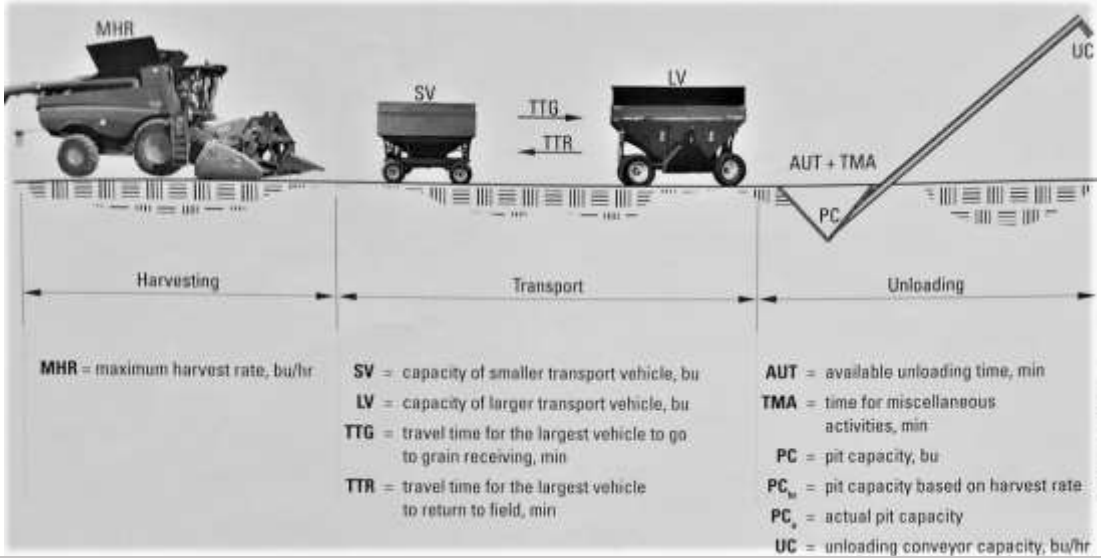
Check your fan performance for your bin.

Do I have sufficient system capacity?

Calculate/estimate capacity at each stage

Know your (system) limitations

Receiving capacity equations and procedures allow estimating of receiving pit capacity and unloading conveyor capacity based on harvest rate and transport vehicle size and speed.



Know your (system) limitations

Drying capacity is a function of:

- daily maximum harvest capacity,
- type of drying system selected,
- amount of automation,
- hours per day of dryer operation.

Know your (system) limitations

- Size conveyors for high capacity when working in batches.
- Low capacity conveyors for continuous flow operations or systems with surge tanks.
- When in series, each downstream conveyor should have 10-15% more capacity.
- Beware of inefficiency and damage when running conveyors at partial capacity.

Minimize Grain Damage

- Before harvest
  - Controlling insect damage
- During harvest
  - Proper combine settings and monitoring
- In conveying
- In drying
- In storage

Minimize Grain Damage

Factors impacting grain condition in storage:	*Why:*
Moisture content and temperature	*Controls the humidity surrounding the grain. Want relative humidity below 65% to limit mold and insect growth.*
Uneven grain temperature/moisture	*Can lead to hot spots in the bin.*
Initial grain quality and test weight	*Low quality grain has poor storability and can cause uneven drying*
Damaged grain (insects, mechanical)	*Mold grows more easily on damaged grain.*
Foreign material/fines	*Can reduce airflow and serve as insect food.*

Minimize Grain Damage

- In conveying
  - Capacity affects bucket, belt, and paddle conveyors only in efficiency
  - Capacity affects augers and pneumatic conveyors in efficiency ***and damage***
- Run augers at or near their capacity
  - Keep intakes submerged
  - Change auger size or speed
  - Note and correct excessive wear

Allowable Storage Time

- **Allowable storage time**: Length of time that grain at a certain ***moisture content*** and ***temperature*** can be stored before losing one quality grade (or about 0.5% dry matter loss).

Allowable Storage Time

Maximum Allowable Shelled Corn Storage Time for 0.5% Dry Matter Loss, Days.[a] (ASABE Standards 2005)

Corn temp	Corn moisture, % wet basis							
°F	16	18	20	22	24	26	28	30
35	1144	437	216	128	86	63	50	41
40	763	291	144	85	57	42	33	27
45	509	194	96	57	38	28	22	18
50	339	130	64	38	26	19	15	12
55	226	86	43	25	17	13	10	8
60	151	58	29	17	11	8	7	5
65	113	43	22	13	9	7	5	4
70	85	32	16	10	7	5	4	4
75	63	24	12	8	5	4	3	3

[a] D = 30%, $M_D = M_H = M_F = 1$, Times calculated using °F temperature values.

Don't use more than half your allowable storage time while holding or storing grain!

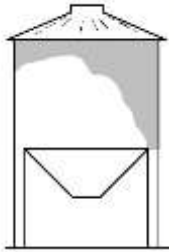
Wet Holding

Drying capacity and receiving capacity can be better coordinated with the addition of wet holding capacity.

- Wet holding must have proper aeration.

Wet Holding

- Suggested wet holding capacity is the difference between daily harvest capacity and drying capacity during that same time period, increased by 50%.
- Aerate wet holding at 0.5 cfm/bu.



Example:
8000 bu./day in 10 hour harvest
Dryer can do 5000 bu. in 10 hours
Holding = 3000 x 1.5 = 4500 bu.

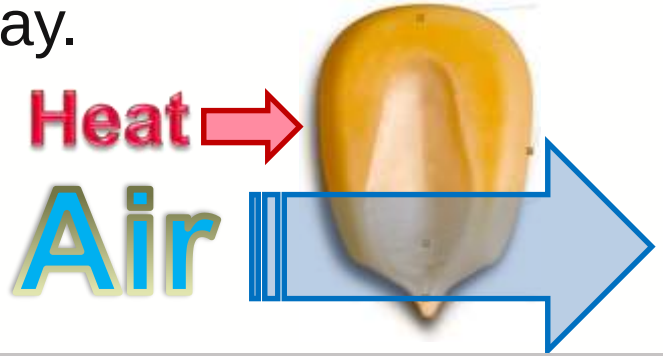
Understand your Drying System

- How grain drying works
- How different drying systems work
- How management affects drying rate and efficiency

Understand your Drying System

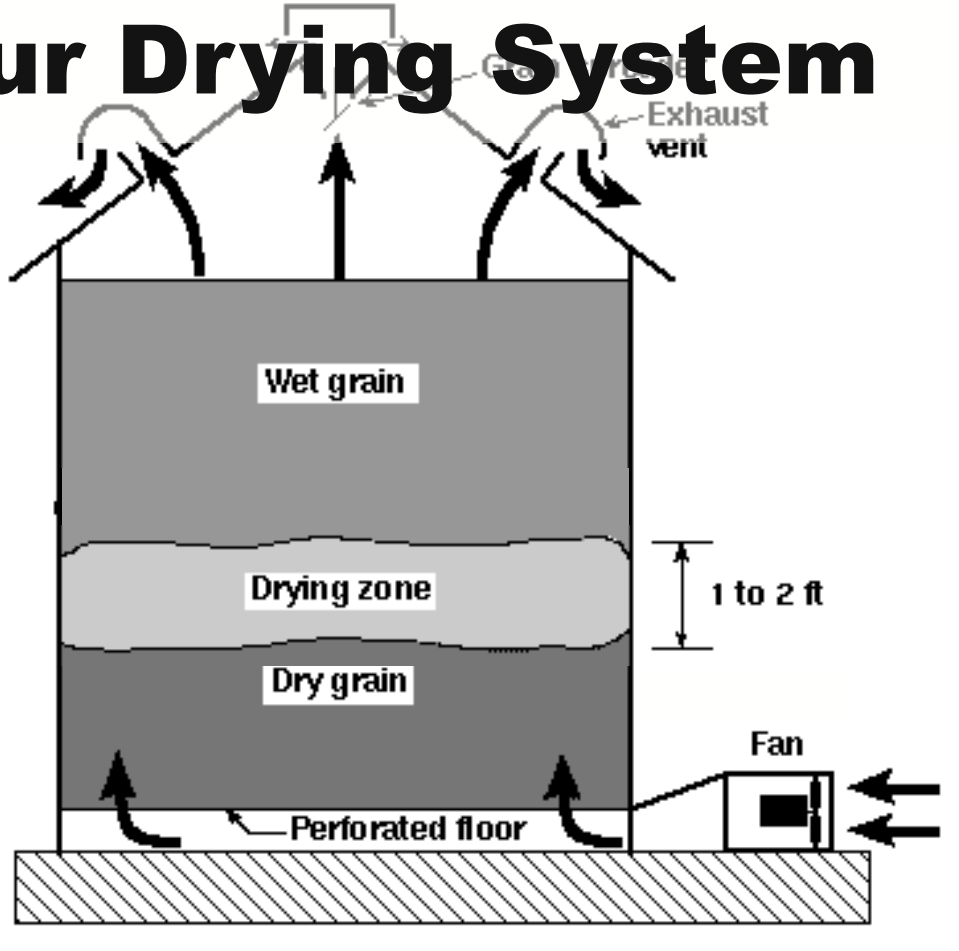
How does grain dry?

- Heat energy evaporates moisture from the kernels.
- Airflow around the kernels with dry air picks up the moisture and carries it away.



Understand your Drying System

Natural Air/Low Temp Bin Dryer



Understand your Drying System

Natural Air/Low Temp Bin Dryer

- Up to 21% corn (with a full bin),
- Requires 1.25-1.50 cfm/bu minimum,
- Relies on favorable air conditions for weeks,
- Becomes inefficient when average daily temperatures are below 40F.

Understand your Drying System

Corn Equilibrium Moisture Content (from MWPS-22)

	Relative Humidity, %						
T, ºF	30	40	50	60	70	80	90
20	12.4	13.6	14.8	16.1	17.6	19.4	22.2
30	11.4	12.7	13.9	15.2	16.7	18.6	21.1
40	10.6	11.9	13.1	14.5	16.0	17.9	20.5
50	9.9	11.2	12.5	13.8	15.4	17.3	20.2
60	9.3	10.6	11.9	13.3	14.8	16.8	19.7
70	8.7	10.0	11.4	12.7	14.3	16.3	19.3

Understand your Drying System

Layer Filling/Layer Drying

- Higher airflow rates are achieved with shallower grain depth.
- Layers 4-5ft deep are added periodically so that wet grain remains ahead of the drying zone.
- A bin with 1 cfm/bu when full may have > 4 cfm/bu when ¼ full.

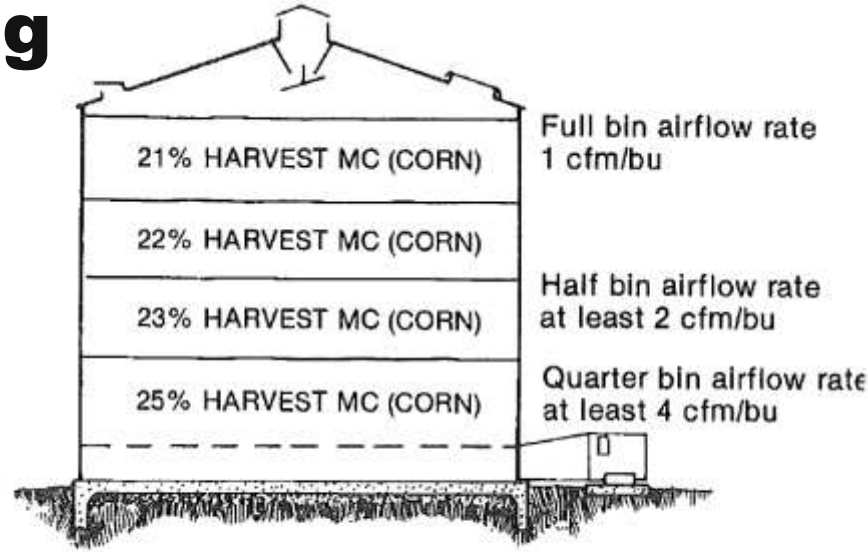
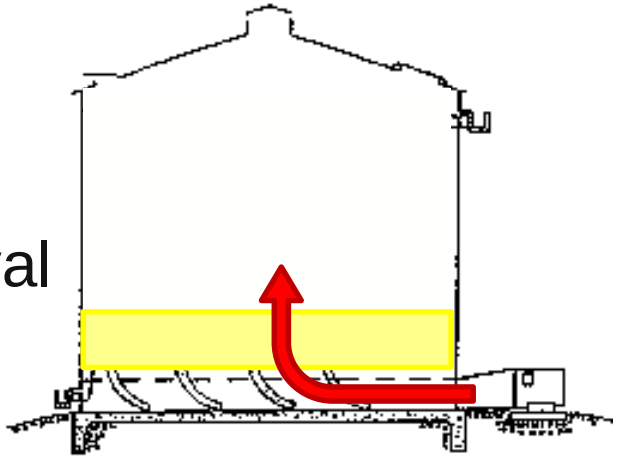


Figure 3. Example of layer drying. The higher airflow rates on a per bushel basis early in the filling permit a higher initial moisture content to be loaded.

Understand your Drying System
High Temp. Batch on floor, no stirring, corn

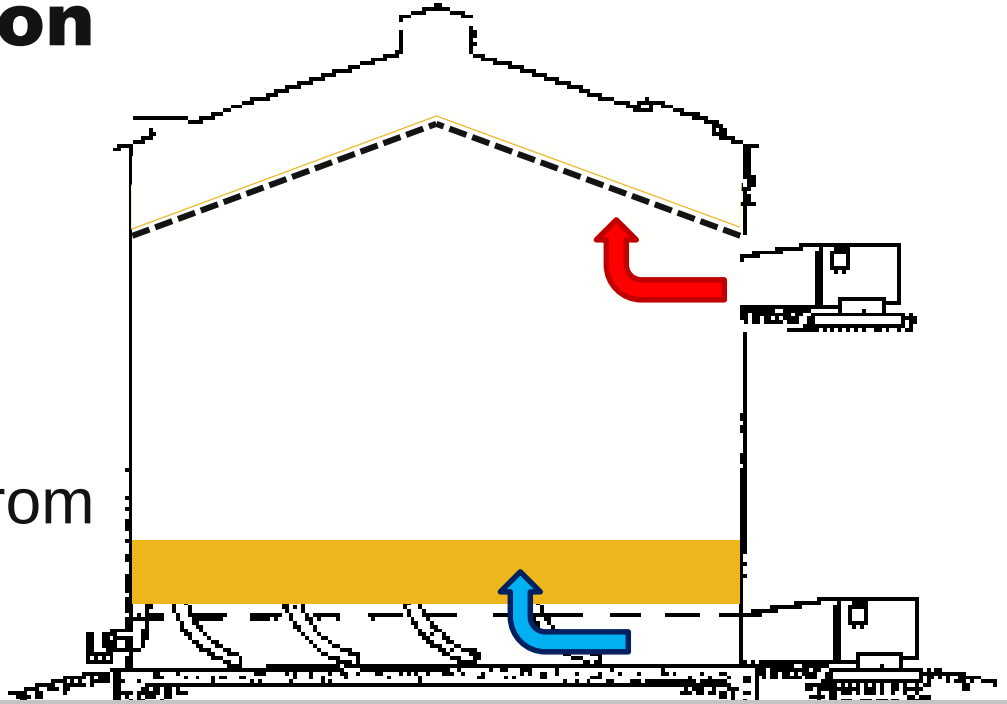
- Requires 5-10 cfm/bushel
  - 2 hp/1000 bu at 2.5 to 4 feet deep
- Depth is limited to limit kernel moisture difference to 5 points
- Temperature of 120 to 180 degrees
- 1-2 batches per day at 10 points removal



Understand your Drying System

Roof Drying Variation

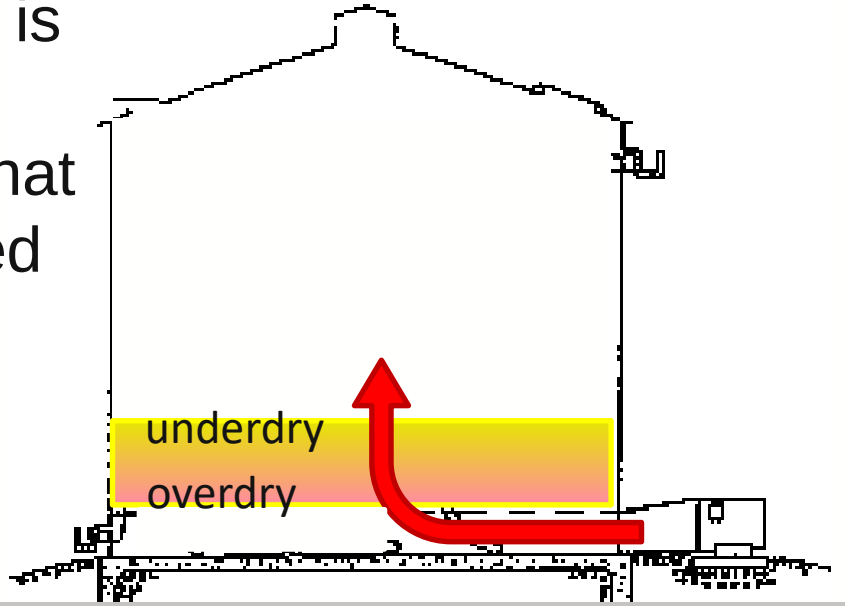
- Similar to batch on floor
- Even shallower layers, more batches per day
- Can dry and cool at the same time
- Recaptures some heat from the cooling portion



Understand your Drying System

Batch on floor, no stirring, corn

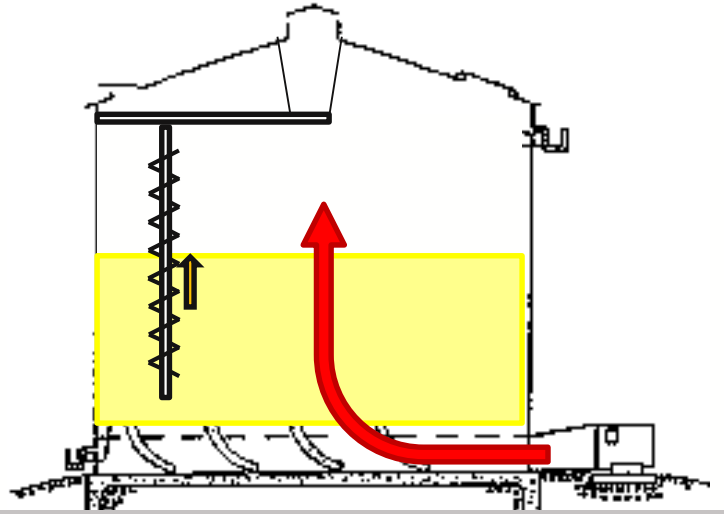
- Equilibrium MC of corn when air is heated to 120 F is less than 5%
- Shallow layers are required so that the difference between over-dried and under-dried kernels is minimized
- Mixing during transfer helps equalize moisture



Understand your Drying System

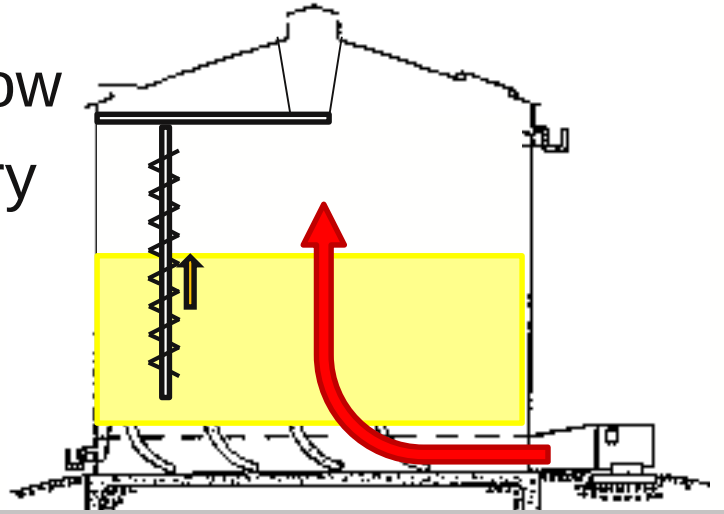
With Stirring Devices, corn

- Can provide more uniform drying and moisture content by blending dried grain with wet grain above.
- Preventing over-drying allows an increase in batch depth.
- Excessive stirring can damage grain.
- Fines may accumulate on bin floor.



Understand your Drying System
With Stirring Devices, corn

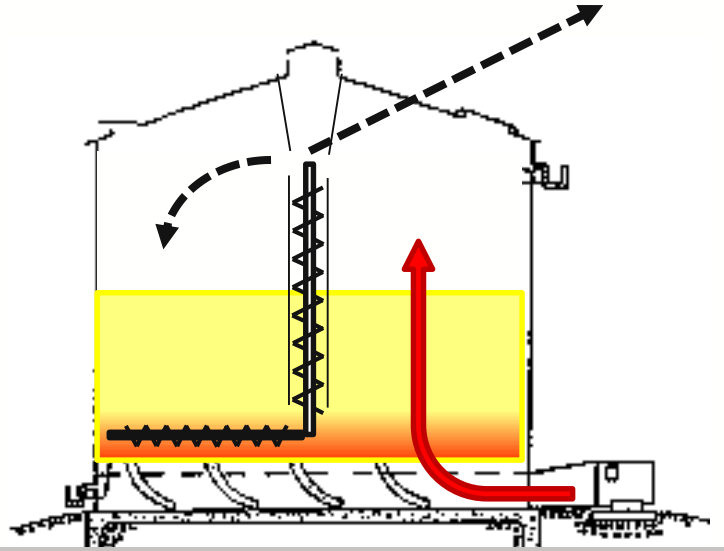
- Requires 5 cfm/bushel
  - 5 hp/1000 bu at 6 to 9 feet deep
- Depth is limited to maintain high airflow
- Stirring must be adequate to move dry grain fast enough to limit over-drying
- Temperature of 120 to 180 degrees
- 2-3 days/batch at 10 points removal



Understand your Drying System

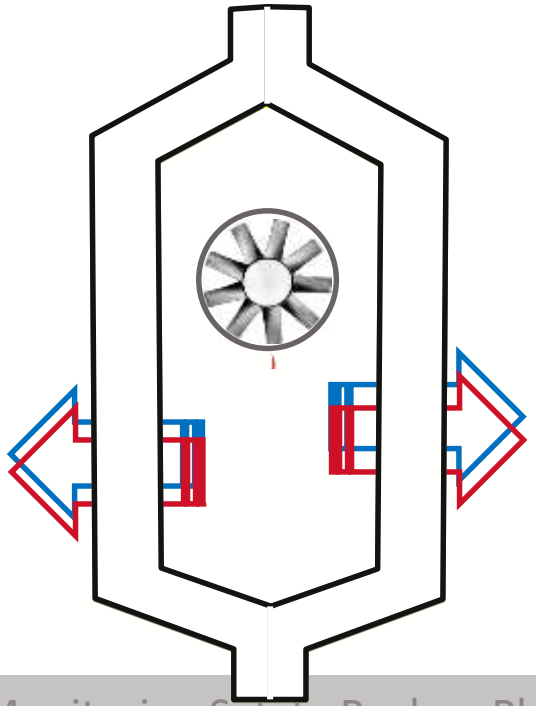
Continuous Counter-flow Variation

- Power sweep and vertical auger remove dry grain from the floor
- Dry grain transferred to storage, or replaced on top of wet grain
- Limits over-drying
- Utilizes waste drying heat
- Provides wet grain holding capacity



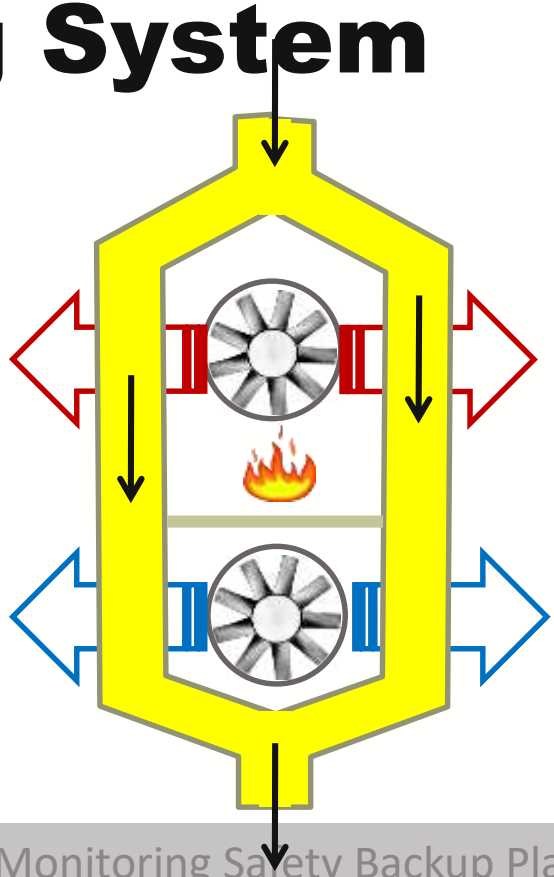
Understand your Drying System

High-Temp Self-Contained



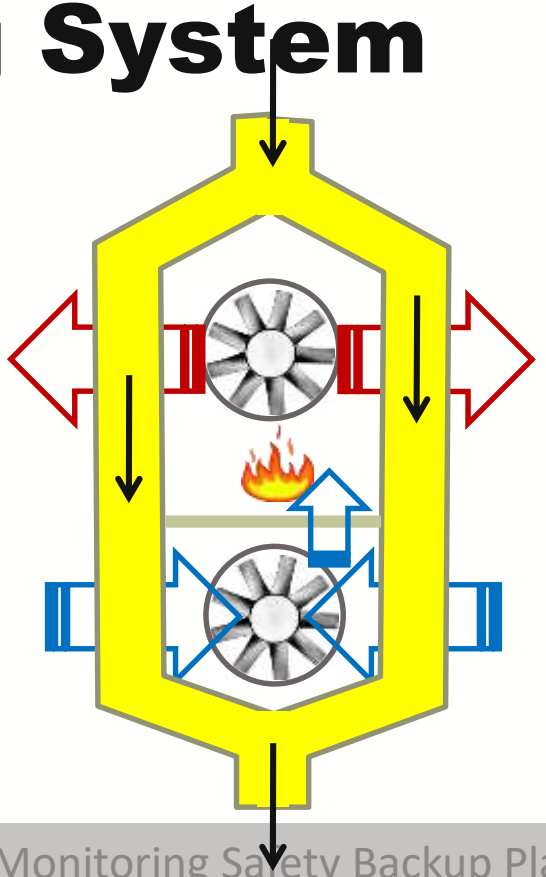
Understand your Drying System

Continuous Flow



Understand your Drying System

Continuous Flow



Understand your Drying System
In-Storage Cooling, corn

- Hot corn is moved directly to storage and cooled slowly in the storage bin.
- Bin must be equipped with an aeration fan that is large enough to keep up with the dryer,

  need 12-15 cfm per bu/hr of dryer capacity.
- Corn will lose 1 to 1.5% points of moisture during cooling.
- Watch out for condensation in the storage bin

Understand your Drying System

Dryeration

- Corn moved hot to a “cooling” bin and tempered (kept hot without cooling) for 4 to 12 hours.
- Corn is then cooled and moved to storage.
- Corn loses about ¼ -% point for every 10F of cooling, typically 2-3% points total.
- Reduces stress cracks.
- 25% energy reduction.
- 30-60% higher dryer capacity - you stop drying sooner.

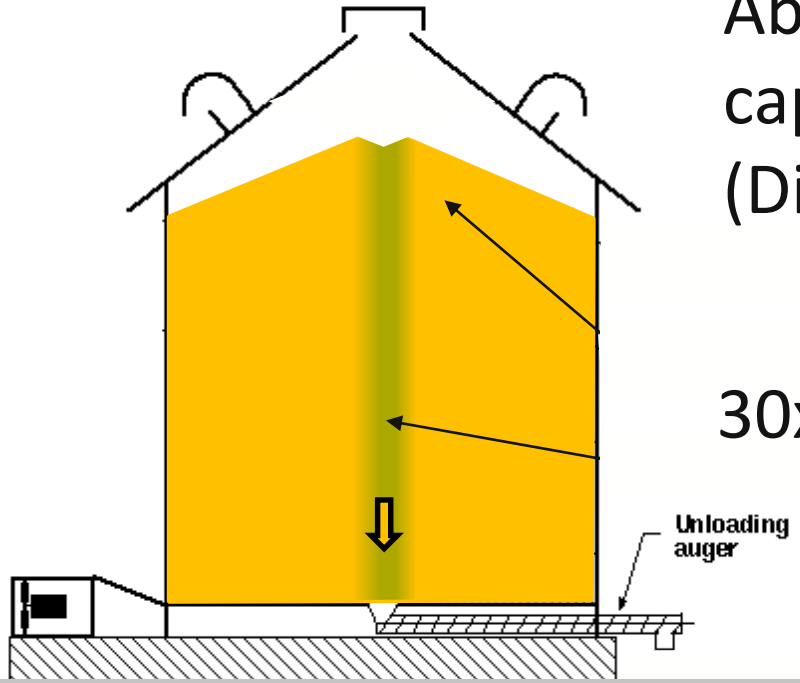
Understand your Drying System

Combination High/Low Temp Drying, corn

Dry in the high-temperature dryer to about 20%, then transfer to low-temperature drying bin to finish drying

- 50% energy reduction vs standard high-temperature drying
- 300% dryer capacity increase (through the high-temp dryer)
- Check moisture meters and equipment often
- Requires both high-temperature dryer and low-temperature drying bins

Core your Bins



Volume of core:
About 1-2% of bin capacity.
$(Diameter)^3 / 100$

30’ bin:
30x30x30= 27000
270 bushels

Control Grain Temperature

Factors impacting grain condition in storage:	*Why:*
Moisture content and temperature	*Controls the humidity surrounding the grain. Want relative humidity below 65% to limit mold and insect growth.*
Uneven grain temperature/moisture	*Can lead to hot spots in the bin.*
Initial grain quality and test weight	*Low quality grain has poor storability and can cause uneven drying.*
Damaged grain (insects, mechanical)	*Mold grows more easily on damaged grain.*
Foreign material/fines	*Can reduce airflow and serve as insect food.*

Control Grain Temperature
Aeration and Cooling

- We want to aerate to:
  - Cool grain for ideal storage conditions,
  - Maintain even temperatures throughout bin.
- Adequate aeration requires at least 0.1 cfm/bu.
- Run a cooling cycle every 10-15 degree decline in outdoor conditions.

Control Grain Temperature

How long does it take to cool grain?

- **Airflow rate is the key**.
- Estimate cooling hours by dividing 15 by your cfm/bu.
- Examples:

Drying fan (1 cfm/bu): 15 ÷ 1.0 cfm/bu = 15 hours

Aeration fan (0.1 cfm/bu): 15 ÷ 0.1 cfm/bu = 150 hours (~6 days)

Control Grain Temperature

Estimating Fan Airflow

U of Minnesota Fans Program: https://bbefans.cfans.umn.edu/

Settings Print

Bin and Crop Inputs

Select a crop:	Shelled corn	**Bin Diameter, feet:**	29
Floor Type:	(•) Full ( ) Duct	**Grain Depth, feet:**	20
		Desired airflow (cfm/bu):	0.5

Estimated Fan Requirements Show Table

(to get desired airflow when bin is full)

Bin capacity (bushels):	10,568
Total airflow (cfm):	5,284
Estimated static pressure (inches of water):	1.56
Estimated fan power needed (hp):	2.16

Control Grain Temperature

U of Minnesota Fans Program: https://bbefans.cfans.umn.edu/

Example section of output table

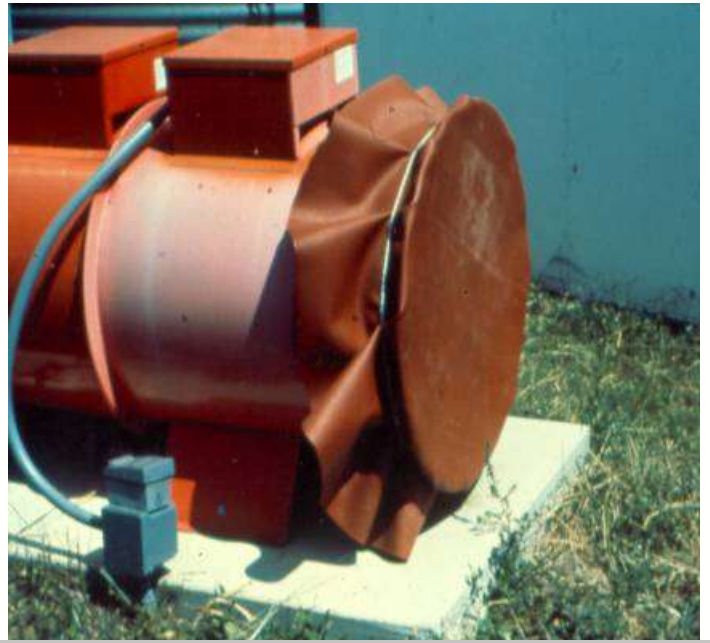
Depth (ft)	Airflow (cfm)	Airflow (cfm/bu)
16	5,241	0.62
18	5,145	0.54
20	5,052	0.48

Control Grain Temperature

- **Fall:** Lower grain temperatures stepwise in 10-15 degree steps until grain temperature is below 35-40 F
- **Winter:** Maintain temperatures below 35-40 F with intermittent aeration as needed
- **Spring:** Keep cold grain cool
    - Seal fans
    - Ventilate headspace to minimize top surface warming

Control Grain Temperature

- Cover fans when not operating,
  - Prevent warm spring air from warming the grain,
  - Keep snow and pests out,
  - Keep out damp air.



Monitor Grain in Storage

- Odor: musty or sour = mold growth
  - Smell the first air that comes out of the grain,
    - With big drying fans, the first flush of air may come out in 30 seconds, so it might take two people.
- Temperature increases in the grain (probes or cables).
- Probe the grain surface for “sticky” spots or heat.

Monitor Grain in Storage

- CO_2 monitors are even better than sensing odor.
  - Under 600 ppm OK, over 1500 indicates serious trouble

Monitor Grain in Storage

- For dry grain:
  - Control temperature around 35 degrees
  - Check grain every 1-2 weeks
  - Use caution when entering bins
  - Have a plan for moving grain if problems develop

Monitor Grain in Storage

- For corn at 15% - 20% moisture:
  - Control temperature around 35 degrees
  - Check grain weekly
  - Finish drying or move **before** mid-spring
    - May store well if monitored and kept cool
    - Warmer spring temperatures will resume grain spoiling

Monitor Grain in Storage

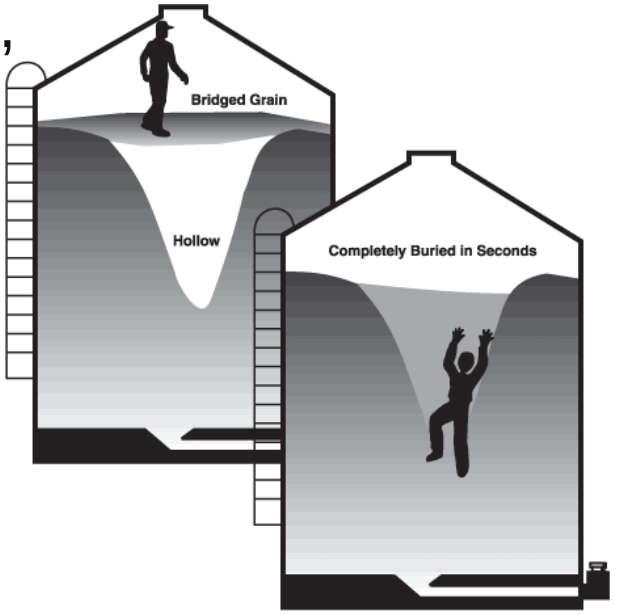
Managing Stored Grain in the Spring & Summer

- Grain must be dry.
- Stored grain insects can be a problem, even in dry grain, if the temperature is too high.
- Maintain grain temperature below 50ºF.
  - Avoid running aeration fans for more than a few minutes when the outdoor temperature is above 50ºF.

Manage for Safety

Caution When Checking Grain!

- Make sure the grain surface looks right,
- Evidence of grain removed,
- Beware of bridged grain,
- Use a partner,
- Use a safety harness,
- Use proper respiratory protection around dusty or moldy grain
- Stay out of flowing grain.



Manage for Safety

Plan for safety with:

1. Access for emergency equipment
2. Space and walkways for maintenance
3. Protected power lines
4. Fall prevention (ladder cages, stairs, landings, railings)
5. Power lock-out and tag-out
6. Signage and hazard marking
7. Grain quality protection

Have a Backup Plan

The best grain storage plan can go bad

1. Monitor weekly to catch problems early
2. Know what you can rescue, and what you need to remove
3. Have a plan for who can/will take bad grain
4. Don’t hesitate – a problem ignored ***WILL*** get worse, not better
5. Call for help as needed

Grain Drying and Storage Resources

- Grain Drying, Handling and Storage Handbook www.mwps.org
- Natural-Air Corn Drying in the Upper Midwest https://extension.umn.edu/corn-harvest/natural-air-corn-drying
- Post-harvest grain information https://extension.umn.edu/corn/corn-harvest
- Web-based training on grain storage: www.iowagrain.org

Thank You

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A Note on Test Weight Increase

- Test weight measures density of grain (pounds per volume bushel)
- Test weight typically increases 0.25 lb. per point of moisture loss (with good quality corn)
  - Kernels shrink and/or pack more densely
  - How much depends on hybrid, mechanical damage, and "gentleness of drying."
- Test weight may not increase for immature corn
- Test weight increase during drying is typically greater for corn dried at low temperature

Test Weight

Question: if your drying system produces higher **test weight**, do you have more weight/bushels of corn to sell?

Answer: NO

- Weight (mass) of grain does not increase.
- It becomes more dense (same mass fits in a smaller space).

See Grain Test Weight Deception:

http://www.extension.iastate.edu/Publications/PMR1005.pdf