High Moisture Corn Drying and Storage

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“Estimated” Corn Field Drying

	EMC (%)	PET (in)	Est. Drying (%pt) Month	Week
Sep	15	4.0-5.0	18	4.5
Oct	16	2.8-3.5	11-12	2.5
Nov	19	0.8-1.2	4-5	1
Dec	20	0.5-0.8	2	0.5
Jan	21	0.5-0.8	2	0.5
Feb	21	0.5-0.9	3	0.8
Mar	19	1.3-1.6	5	1
Apr	16	3.2-4.5	16	4
May	14	6.5-8.5	30	7

NDAWN, Weather, Total PET, Estimate:1-inch = 4% drying
EMC-equilibrium moisture content,
PET=Potential Evapotranspiration

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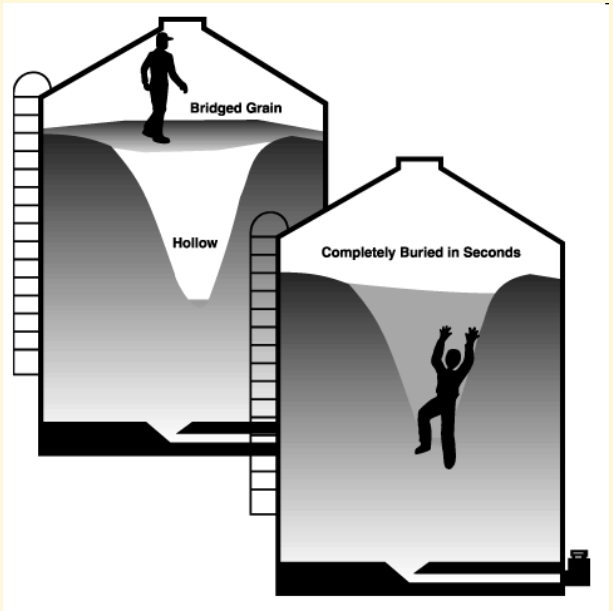
Moisture Meter Error

- Calibrated for 15% corn – error on high moistures
- Adjust for temperature
  - Not accurate <40°F
- Electronic meters more sensitive to outside of kernel
  - Moisture variation after rapid drying
- Meters affected by condensation

- Measure moisture content
- Place sample in sealed container
  for several hours (6-12 hrs)
- Warm to 70°F
- Recheck moisture

Corn Flowability

- 28% moisture freezes together
- 24% - 25% some binding
- <24% to assure flow
- Foreign material affects flow



Danger!

25% - 30% Moisture Corn

- Pile so can mechanically load
- 28% corn @ 40°F, AST = 30 days
- Aerate to keep corn temperature <30°F
- High Temperature Dry by early February

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Holding 22% - 24% Corn

- Cool to 20°F
- High temperature dry by early March
  - Deterioration in early spring (AST)

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Grain Temperature

Average Maximum Air Temp.

February 1 - 15°
March 1 - 27°
April 1 - 45°
May 1 - 65°

Solar Radiation (Btu / ft²-day)

	Wall	Roof
Feb. 21	1725	1800
Jun. 21	800	2425

Periodically Cool
Keep under 30°F

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Let Stand Over Winter

- Spring (March) moisture content ≈19-21%
- Field losses unknown – Check stalk & shank
- Snow accumulation 40”= 4” water

HT Dry vs. Stand Over Winter

Propane Drying Cost Per Point Moisture per Bushel vs. Harvest Loss

- $0.02 X Propane Price
- $0.02 X $2.00/gal. = $0.04 per point/bu.
- @ 10 pts. = $0.40/bu.
- @ $3.00 corn
- $0.40/bu. / $3.00 = 0.13 = 13%
- @ 120 bu./ac. = 16 bu./ac.

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Uncovered Piles

- 1-inch rain increases moisture content of 1 ft. of corn by 9 percentage points
- Grain 43% voids - Water will not run off before a crust forms?

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Grain Piles

- Prepared bottom surface
- Negative pressure holds cover
- **Designed and managed**

aeration is critical for piles.

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Poly Bag Storage

- **Sealed bag does not prevent mold growth or insect infestation.**
- **Grain must be dry!**
- **Run bags north-south**
- **Create soft elevated surface for bags**
- **Grain temperature follows average outdoor temperature.**

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High Temp. Dryer Management

- High temperatures, fast drying, fast cooling creates stress cracks, broken kernels & lower final test weight
- High moisture increases scorching potential - Reduce plenum temperature

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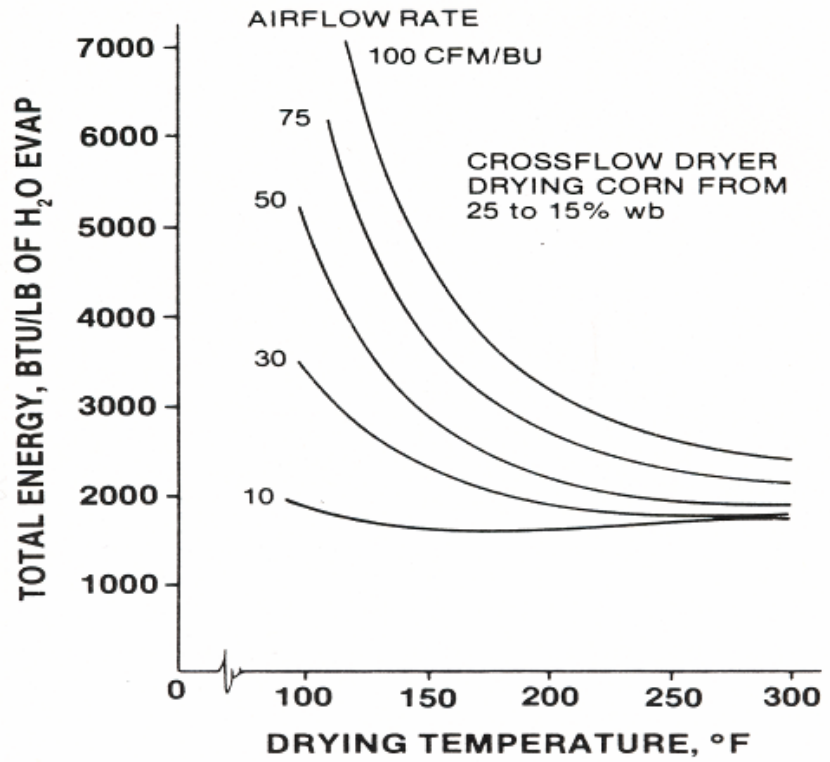
Energy requirements of a conventional cross-flow dryer as a function of drying air temperature and airflow rate.



Energy required to remove a pound of water is reduced at higher plenum temperatures and lower airflow rates.

Use the maximum temperature that will not damage the grain.

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NDSU AE-701

(University of Nebraska)

Drying Energy Cost Estimation

High Temperature Drying~210°F

Assumes 2,500 Btu/lb water

Propane cost / bu.- point moisture = 0.02 x price/gal

0.02 x $2.00/gal = $ 0.04/bu.-pt.

0.02 x $1.50/gal = $ 0.03/bu.-pt.

@ $2.00/gal propane, estimated propane cost to dry corn from 26% to 16% is $0.04/bu.-pt. x 10 pts = $0.40/bu.

At 2,000 Btu/lb. = 0.018 x Propane Price

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Fuel Cost

Cost per bu. $1.85 gal. Propane, $.10/kWh	
5% Pt. Removal	
Pressure Heat Pressure Cool	16.0
Full Heat	13.1
Pressure Heat Vacuum Cool	12.5
Pressure Heat Vacuum Cool Heat Reclaim	9.0

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Estimate Propane Quantity Needed

Propane gallons = 0.02 x bu. x point moisture

Propane = 0.02 x 1,000 bu x 10 pts = 200 gallons

Based on 2,500 Btu/lb.

For 2,000 use 0.016/bu. pt.

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Test Weight Increase When Drying

Adjustment added to the corn wet-harvest test weight to obtain an expected test weight after drying to 15.5 percent moisture.

Test Weight Adjustment (lb/bu.)								
Harvest Mechanical Damage (Percent)	Harvest Moisture Content (Percent)							
	30	28	26	24	22	20	18	16
45	0.3							
40	0.7	0.2						
35	1.3	0.7						
30	1.8	1.3	0.8					
25	2.4	1.9	1.4	0.9	0.3			
20	3.1	2.6	2.0	1.5	1.0	0.5		
15	3.8	3.2	2.8	2.2	1.7	1.2	0.6	0.2
10	4.5	1.0	3.5	2.9	2.2	1.9	1.4	0.8
5	5.3	4.7	2.2	3.7	3.0	2.7	2.1	1.6
0	6.1	5.6	5.0	4.5	4.0	3.5	2.9	2.4

Affected by:

*** Kernel Damage**

*** Drying Temperature**

*** Variety**

Normally ¼ to 1/3 lb/pt.

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Moisture Shrink

(Weight loss due to moisture loss)

$$\text{Moisture Shrink (\%)} = \frac{Mo - Mf}{100 - Mf} \times 100$$

Example: Corn dried from 25% to 15% moisture

$$\text{Shrink\%} = \frac{25\% - 15\%}{100\% - 15\%} \times 100 = 11.76\%$$

Shrink Factors

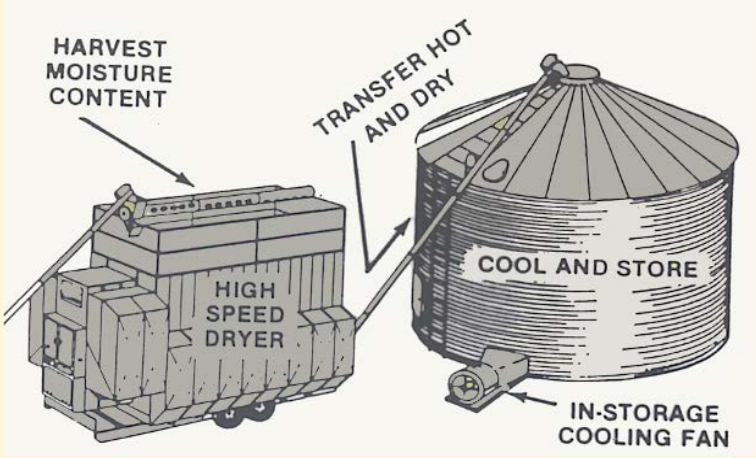
(% weight loss/percentage point moisture loss)

15.5%	1.1834
13.5%	1.1561
13.0%	1.1494
10.0%	1.1111

Example: The moisture shrink drying corn from 25.5% to 15.5% is

10pts x 1.1834 = 11.8%

In-Storage Cooling



- Immediately cool, Airflow rate ≈ 12 cfm/bu-hr of fill rate
- About 1-1.5 percentage point moisture reduction (0.1 – 0.15 / 10ºF)
- Reduce condensation if outdoor temperature is below 50ºF by partial cooling in the dryer – typically to about 90°F

In-storage cooling requires rapid cooling and cooler initial grain temperature to limit condensation. Slow cooling saves more energy, but storage problems typically occur near the bin wall.

Natural Air and Low Temperature Corn Drying

21% Initial Corn Moisture Content, Average ND Climatic Conditions

				Drying Time (Days)	
Month & added heat	Temp. (°F)	RH	EMC	1.0 cfm/bu	1.25 cfm/bu
Oct. +3°F (fan)	50	58%	13.5%	42	34
Oct. 15 – Nov +3°F (fan)	37	66%	15.8%	65	52
Nov. +3°F (fan)	30	64%	16.0%	70	56
Nov. +3°F (fan)+2°F	32	58%	14.6%	65	52
Nov. +10°F	37	48%	12.5%	51	41

Using a humidity controlled heater reduces the potential for over-drying the corn

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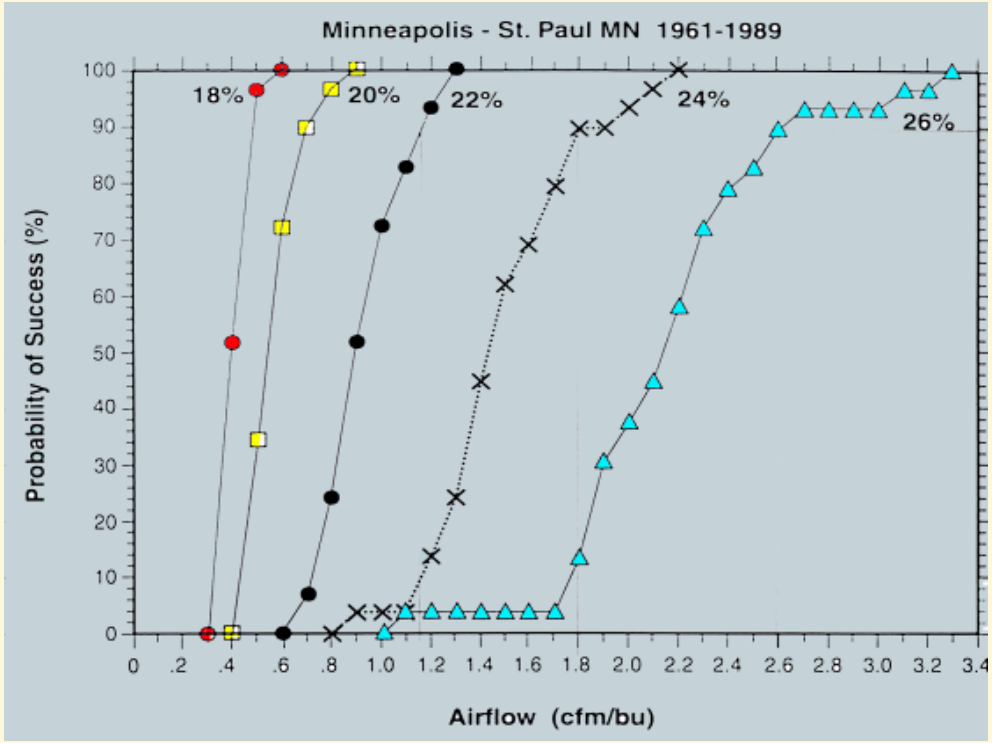
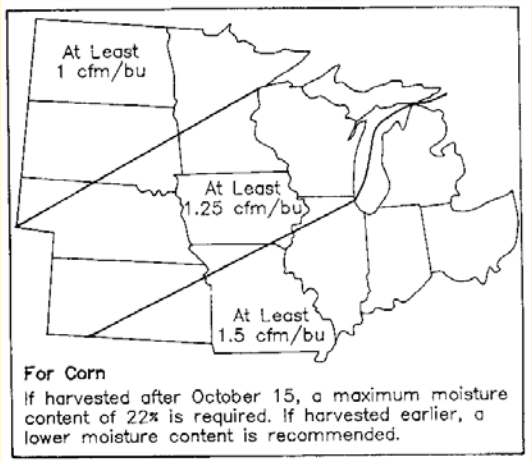
Minimum Recommended Airflow Rate For Natural Air Drying Corn



Airflow Rate (cfm/bu)	Moisture Content (%)
1.00	21
1.25	22
1.5	23
2.0	24
2.3	25



Wilcke and Morey, University of Minnesota Bu-6577-E, 1995

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Fan Power Required

Energy efficiency maximum depth about 22 ft. and airflow rate about 1.0 cfm/bu.

	Corn Depth (ft)				
Airflow Rate	16	18	20	22	24
(cfm/bu)	----- hp per 1,000 bu -----				
1.0	0.6	0.8	1.1	1.3	1.7
1.25	1.1	1.4	1.8	2.3	2.9
1.5	1.7	2.2	2.9	3.6	4.5

Horsepower calculated based on a 42 ft diameter bin

42 ft diameter bin, corn 36 ft deep, 1.0 cfm/bu

Fan = 180 hp, static pressure = 17-inches wg.

Air Drying

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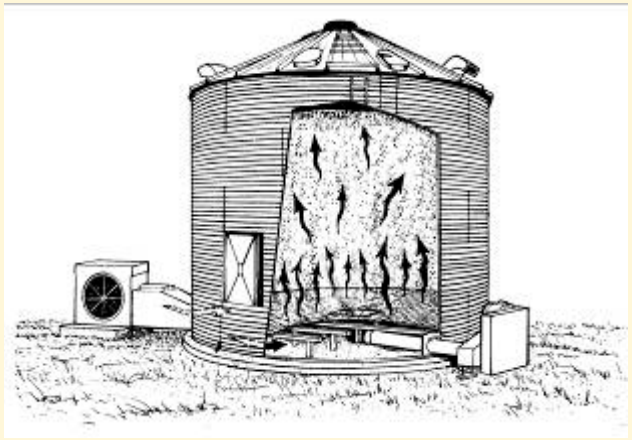
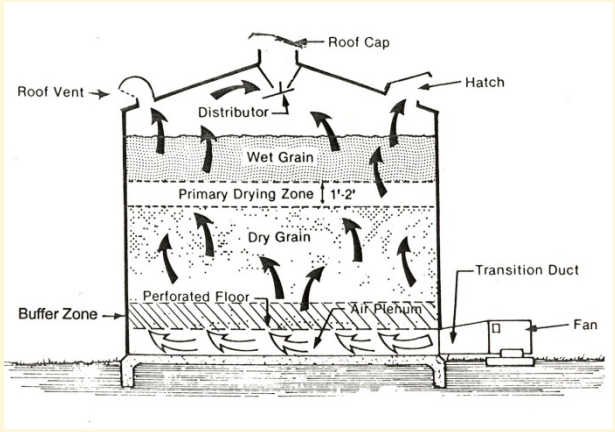
- 21% Maximum moisture content
- 1.0 cfm/bu. minimum airflow rate
- Start when fall temperatures average <50°F
- Cool to 20-30°F for winter storage
- Start drying when temperature average >40°F





Condensation may freeze over vents when outside air temperatures are near or below freezing

Leave fill and access open

Iced over vents will damage bin

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Storability

Cracked, broken, immature corn spoils easier

Test weight is an indicator of storability

Variety variation

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"Approximate" Allowable Storage Time for Cereal Grains (Days)

Moisture	----- Grain Temperature (°F) -----					
Content	30°	40°	50°	60°	70°	80°
(%)	Approximate Allowable Storage Time (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

* Exceeds 300 days

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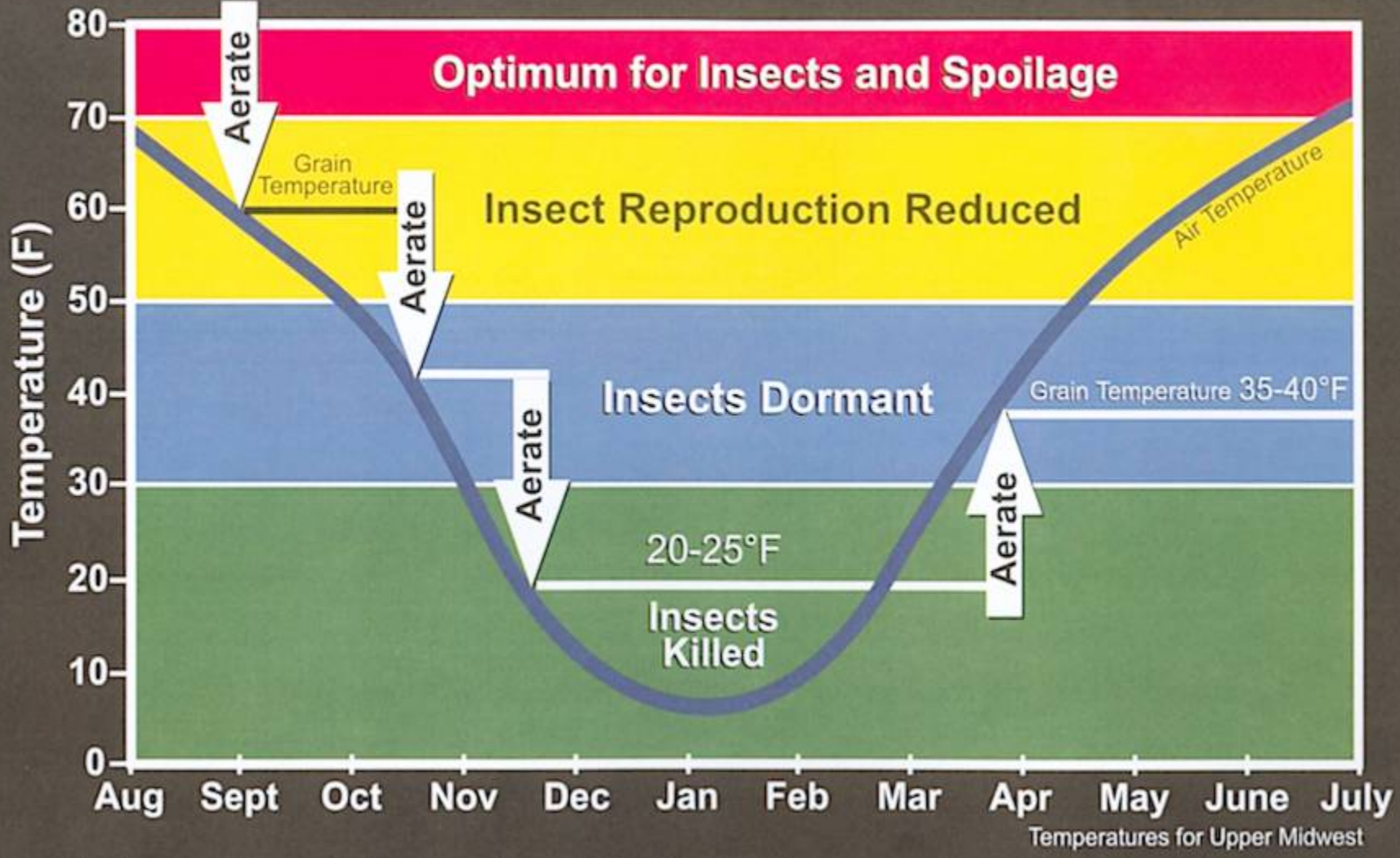
Cool Grain to Prevent Storage Problems



* Prevent crusting due to moisture migration by cooling grain to within 15°F of average outdoor temperatures.
* Cooling grain by 10°F doubles its allowable storage time

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Grain Hazards

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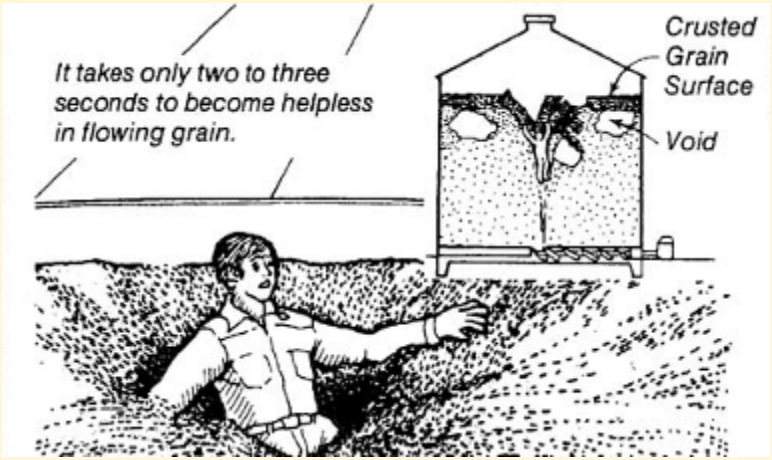
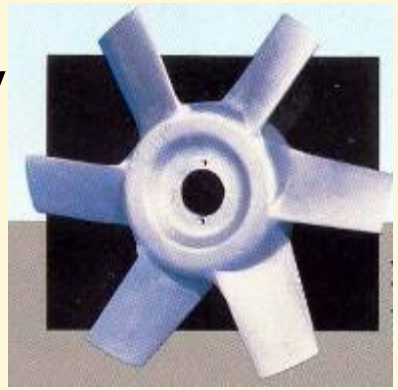
Bridging transfers load to the bin wall



CAUGHT IN THE GRAIN!
AE-1102

Moldy Grain Health Hazard

Ice on blade may cause it to disintegrate



For More Information

Internet Search: NDSU Grain Drying & Storage

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