

Grain Storage Best Management Practices



International Crop Expo
February 20, 2020

Kenneth Hellevang, Ph.D., P.E.
Extension Engineer & Professor
Agricultural & Biosystems Engineering



EXTENDING KNOWLEDGE >> CHANGING LIVES

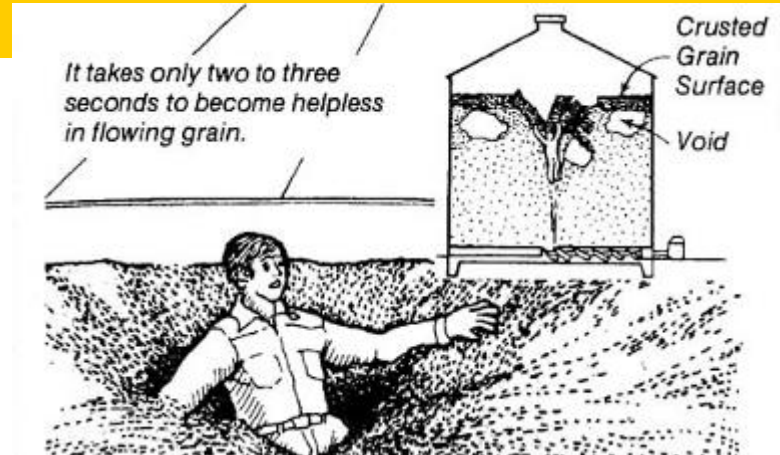
NDSU

EXTENSION

Grain Hazards



Bridging transfers load to the bin wall



**CAUGHT IN THE GRAIN!
AE-1102**



Moldy Grain Health Hazard

“Approximate” Allowable Storage Time for Cereal Grains (Days)

Cumulative

* Exceeds 300 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

Storability

- **Cracked, broken, immature grain spoils easier**
- **Test weight is an indicator of storability**
- **Variety variation**



Moisture Measurement



- **Adjust for temperature**
 - **May not be accurate $<40^{\circ}\text{F}$**
- **More sensitive to outside of kernel**
 - **Moisture variation after drying**
 - **Meters affected by condensation**



Recommend:

- **Place sample in sealed container**
- **Warm to $\sim 70^{\circ}\text{F}$**
- **Equilibrate moisture for 6-8 hours.**
- **Check moisture**

Recommended Long-Term Storage Moisture Content

HRS Wheat



EMC = 13.3%

Air



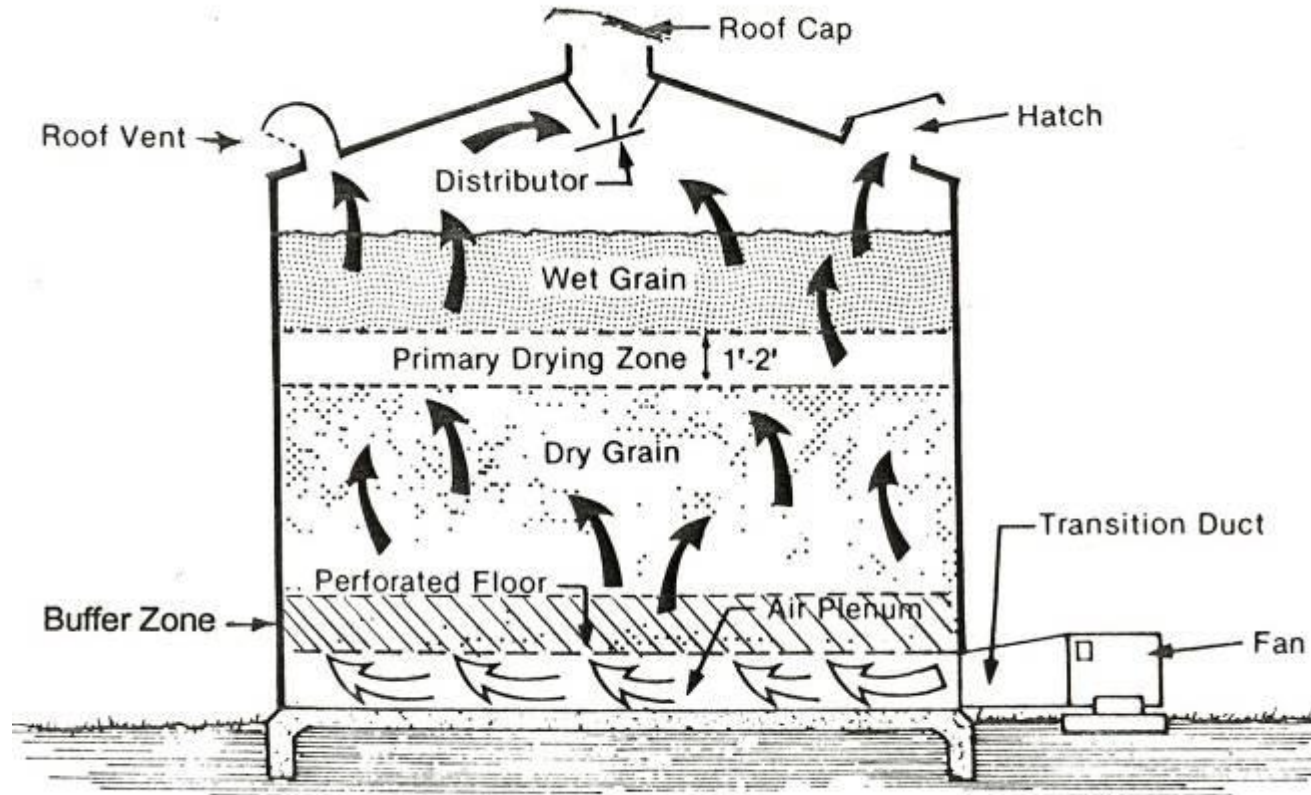
Mold Growth > 70% RH



Grain	EMC @ 70°F, 60% RH	Moisture
Barley	11.8%	12%
Canola	8.0%	8%
Corn	12.8%	13%
Flaxseed	8.3%	8%
Soybeans	10.2%	11%
Sunflower Non-Oil	9.6%	10%
Oil	7.4%	7- 8%
Wheat	13.3%	13.5%



Natural Air Drying



Natural Air and Low Temperature Corn Drying

NA/LT corn drying works well until outdoor temperatures approach freezing.

				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

21% Initial Corn Moisture Content, Average ND Climatic Conditions

Natural Air & Low Temperature Corn Drying Spring Drying

				Drying Time (Days)	
Month & added heat	Ave. Temp (°F)	RH	Corn EMC	1.0 cfm/bu	1.25 cfm/bu
Apr	42	65%	15.3%	51	41
+5°F	47	54%	13.3%	46	37
May	56	60%	13.5%	43	34

Natural air drying is very efficient in the spring. Start fans when outdoor temperatures average about 40 F.

Natural Air Drying Soybeans

Final Moisture Content \approx 11% Airflow Rate = 1.0 cfm/bu.

Month	Temp °F	R.H. %	Initial Soybean Moisture Content									
			20%		18%		16%		15%		14%	
	+3F Fan		Dry	AST	Dry	AST	Dry	AST	Dry	AST	Dry	AST
April	45	63%	60	36	60	58	62	100	61	140	45	200
May	59	58%	39	13	38	20	33	35	32	50	24	75
June	68	60%	39	7	38	11	33	20	32	30	24	45

Maximum moisture content for air drying is about 15% to 16% with an airflow rate of at least 1.0 cfm/bu. Start drying when outdoor temperature averages about 40°F.

Fire Hazard Drying Soybeans

- Pods and trash become lodged and combustible
- Keep grain flowing
- Keep dryer clean
- Monitor dryer

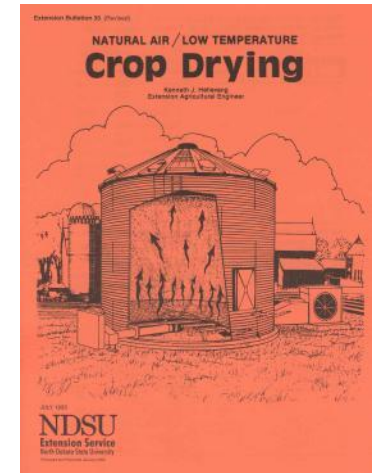


Airflow Rates and Drying Times

Natural air drying wheat

air at 69° and 60% relative humidity, average North Dakota condition for August.

Moisture Content	Airflow (cfm/bu)	Fan Time	
		Hours	Days
18%	1.25	480	20
	1.00	600	25
17%	1.00	552	23
	0.75	744	31
16%	1.00	504	21
	0.75	672	28
15%	0.50	1,008	42
	1.00	480	20
14%	0.75	648	27
	0.50	960	40
13%	1.00	408	17
	0.75	544	23
12%	0.50	816	34



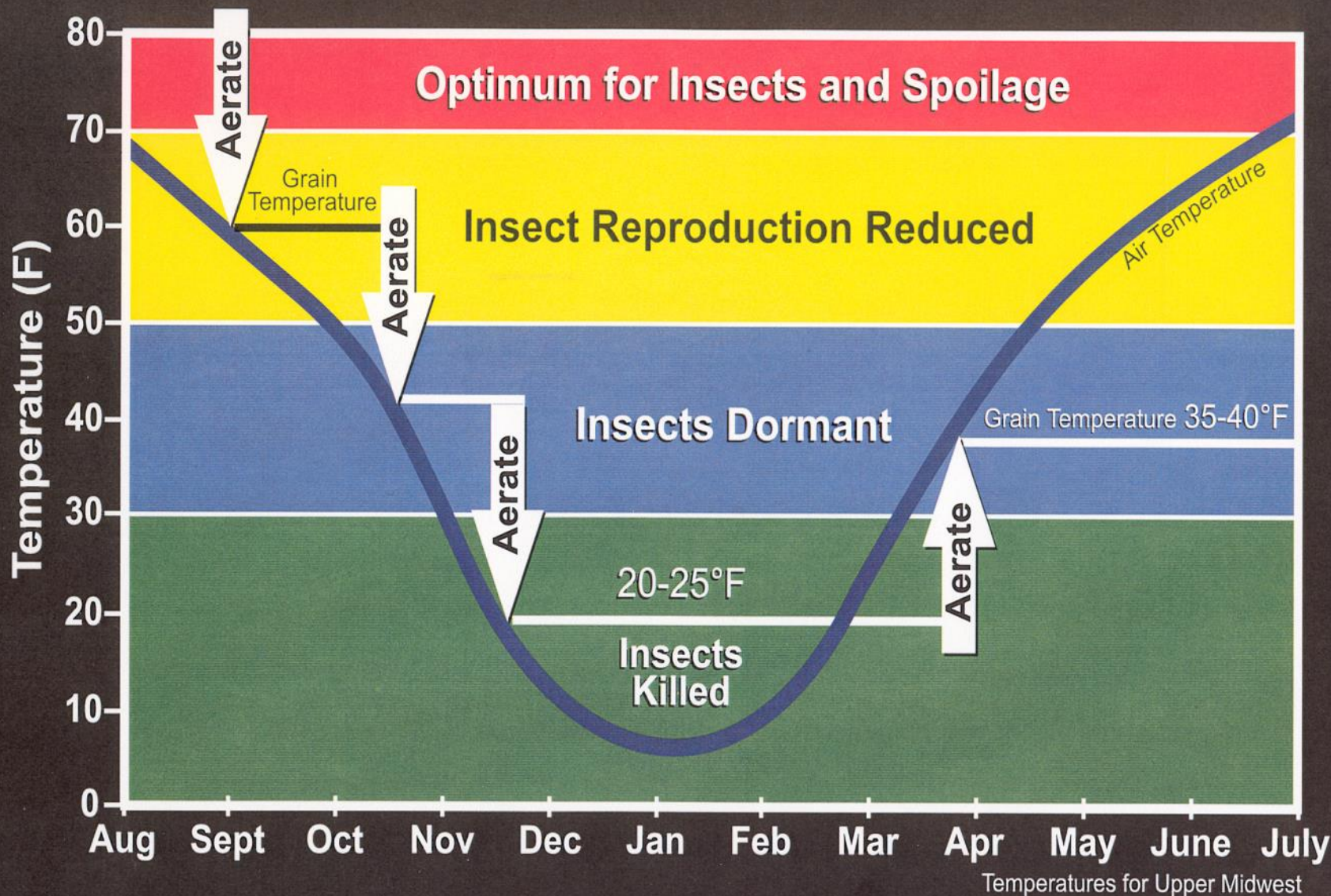
Wheat Drying Time



17% initial M.C., 0.75 cfm/bu, +3° F fan

Month	Temp.	RH	+3° Temp	+3° RH	EMC	Days	%↑
Aug.	69	60%	72	54%	12.6%	26	
Sep/ May	58 56	65% 60%	61	58%	13.5%	31	20%
Oct/ Apr	47 42	65% 65%	50	58%	13.9%	39	50%
Nov/ Mar	27 24	73% 73%	30	63%	15.6%	75	300%

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

Control Insects by Cooling

Grain Temperature (F)	Insect Impact
77-90	Optimum reproduction
55-75	Reduced activity
37-41	Dormant
14-32	Death in weeks
< 0	Death in hours
Adapted from Fields 1992	

All the grain must be warm to fumigate!

Calculate Aeration Time

Cooling Time

Time (hrs.) = 15 / Airflow rate (cfm/bu.)

Time (hrs.) = 15 / 0.2 cfm/bu.

Time (hrs.) = 75 hrs.



Example:

42' diameter, 36 ft. depth, 40,000 bu. of Soybeans

5 hp. LSC Fan, 0.21 cfm/bu.

Cooling time = 72 hrs.

Spring Grain Cooling



Solar Radiation (Btu/ft²-day)

	<u>Wall</u>	<u>Roof</u>
Feb. 21	1725	1800
Jun. 21	800	2425



ND	Average Temperature	Minimum Temperature
Mar	25	16
Apr	41	29
May	55	43

Periodically Cool!

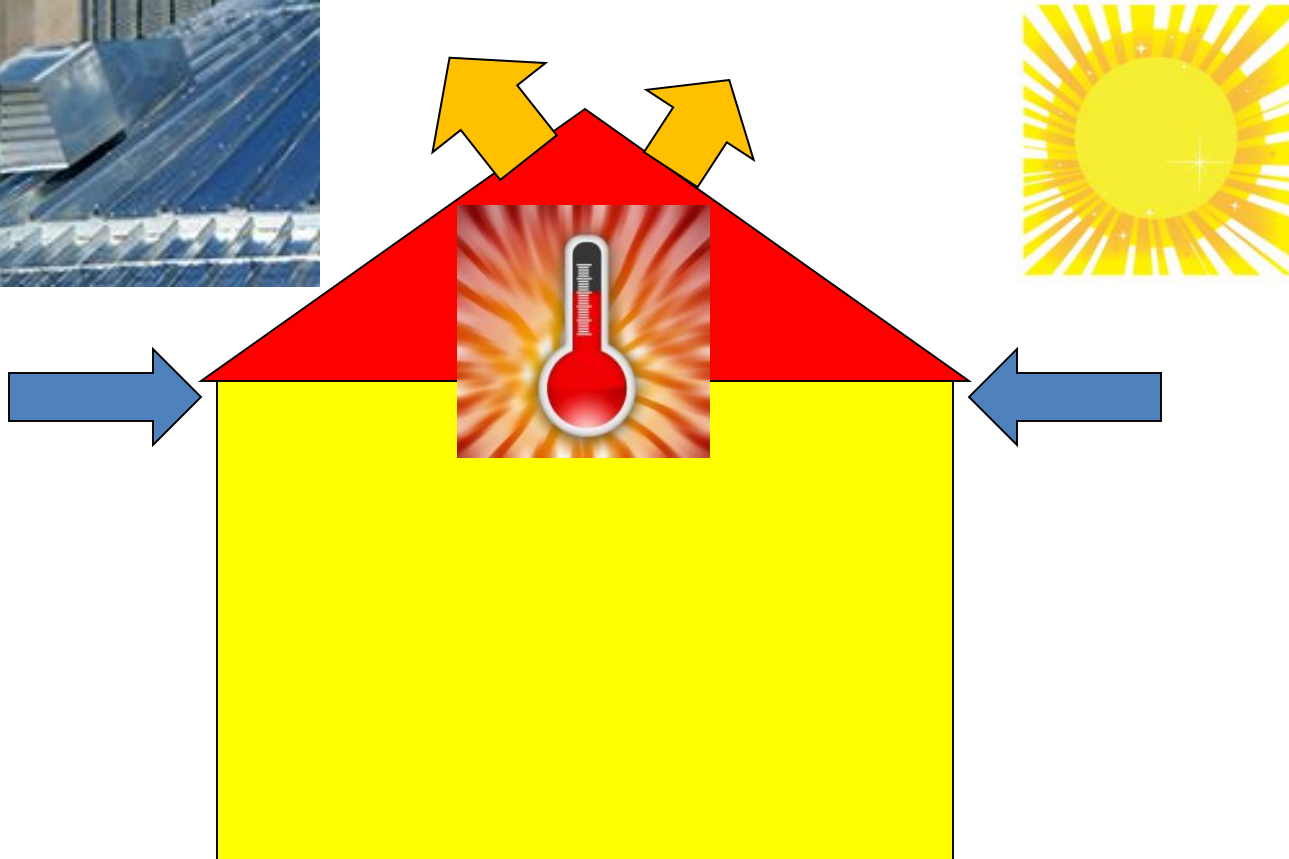


North Central Region States

Average Monthly Maximum and Minimum Temperature, F

		ND	SD	NE	KS	MN	IA	MO	WI	IL	MI	IN	OH
Jan	Max	16	27	36	39	19	31	38	23	36	30	32	36
	Min	-3	7	14	19	-1	14	21	6	19	17	16	20
April	Max	52	59	63	67	55	62	66	55	66	58	62	63
	Min	29	34	38	43	34	41	44	33	43	37	38	41
July	Max	80	86	88	93	82	86	88	80	87	82	84	85
	Min	57	61	65	69	61	67	67	59	66	61	62	65
Oct	Max	55	60	65	70	58	63	67	55	68	60	64	65
	Min	32	35	40	46	36	43	45	37	45	41	41	44

Ventilate Bin Headspace



Fan Selection Program

UNIVERSITY OF MINNESOTA
Driven to Discover™

myU > One Stop >

Search U of M Web sites Search

Department of
Bioproducts and Biosystems Engineering
Sustainable Use of Renewable Resources – Enhancement of the Environment

University of Minnesota Fan Selection for Grain Bins

Home
About Us
Undergraduate Programs
Graduate Program
In the News
People
Research
Career Resources
Extension and Outreach
Giving
Contact Us

College of Food, Agricultural and Natural Resource Sciences
UNIVERSITY OF MINNESOTA

COLLEGE OF Science & Engineering
UNIVERSITY OF MINNESOTA

UNIVERSITY OF MINNESOTA
EXTENSION

Background Show Background

Settings Print

Bin and Crop Inputs

Select a crop: Barley
Floor Type: Full Duct
Bin Diameter, feet: 21
Grain Depth, feet: 20
Desired airflow (cfm/bu): 1

Estimated Fan Requirements Show Table

(to get desired airflow when bin is full)

Bin capacity (bushels):	5,542
Total airflow (cfm):	5,542
Estimated static pressure (inches of water):	7.12
Estimated fan power needed (hp):	10.34

Fan Selection Show Fan Data

Select a fan: 0.33 hp AEROVENT 1240-DW | 12" (Axial) Add a New Fan
Fan arrangement: Parallel Series
Number of fans on bin: 1

Results

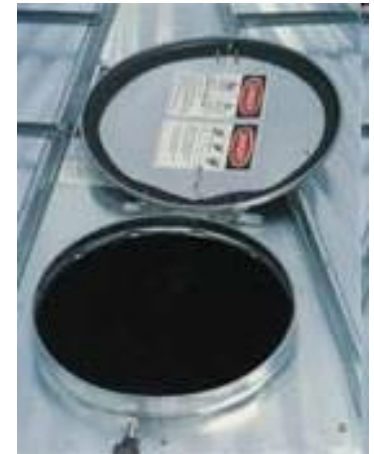
Airflow vs Depth Table Airflow Graph System Graph

Fans Off During Snow/Rain/Fog



WARNING

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



**Iced over vents
will damage bin**



Pressure Switch

**Leave fill and
access open**

Cover Fans When Not Operating



- Keep snow & pests out
- Prevents spring warm-up
- Keep damp air out

Manage - to direct with a degree of skill



Monitor:

- Temperature
- Moisture
- Insects
- Mold

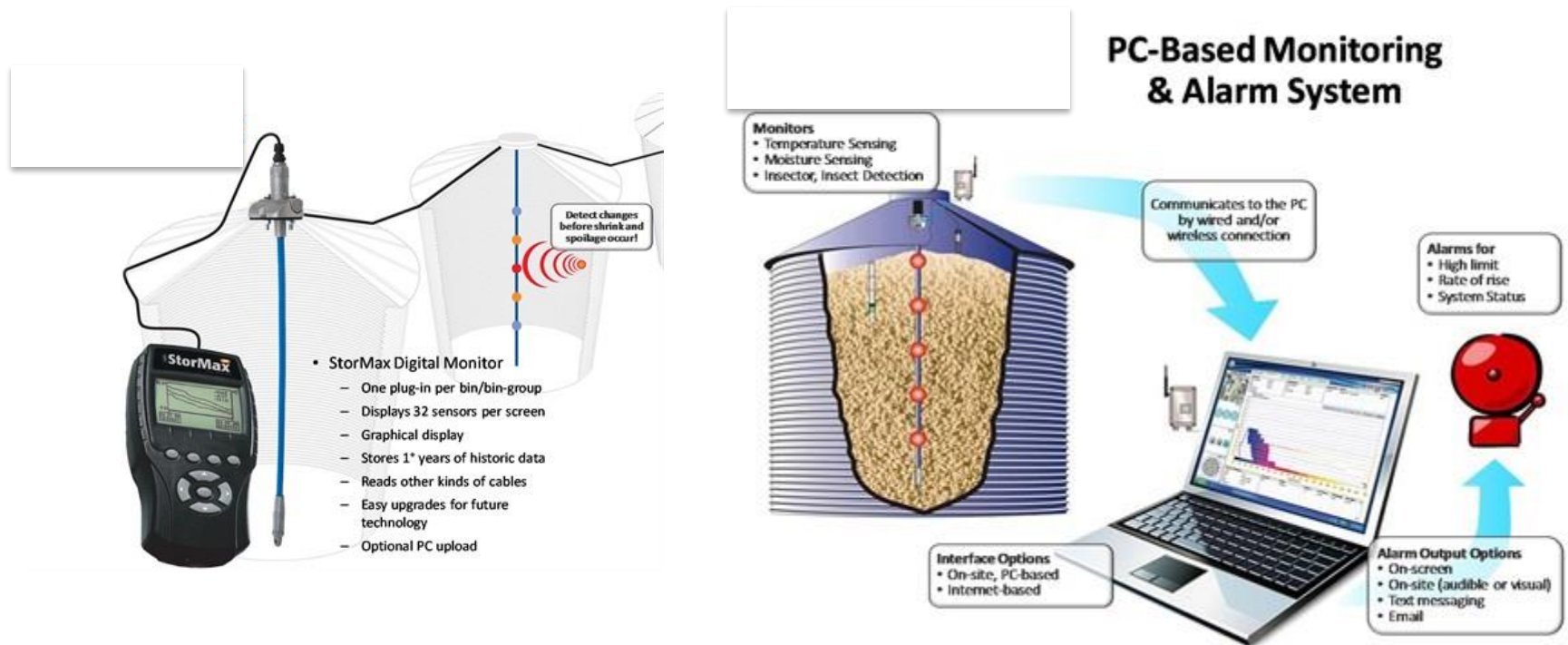
Check Grain

- 2-weeks until cooled
- 2-3 weeks during winter
- 2-weeks spring & summer

Manage: Aerate & Dry

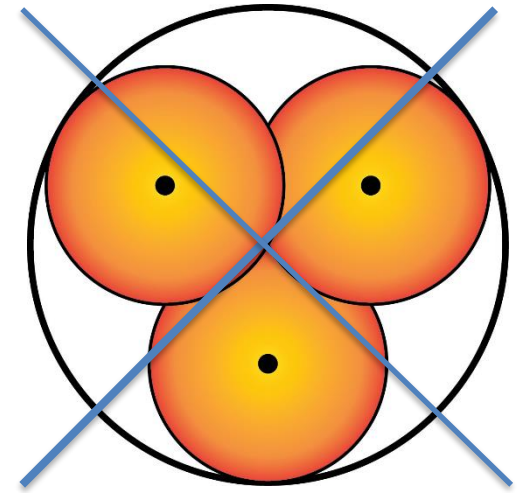
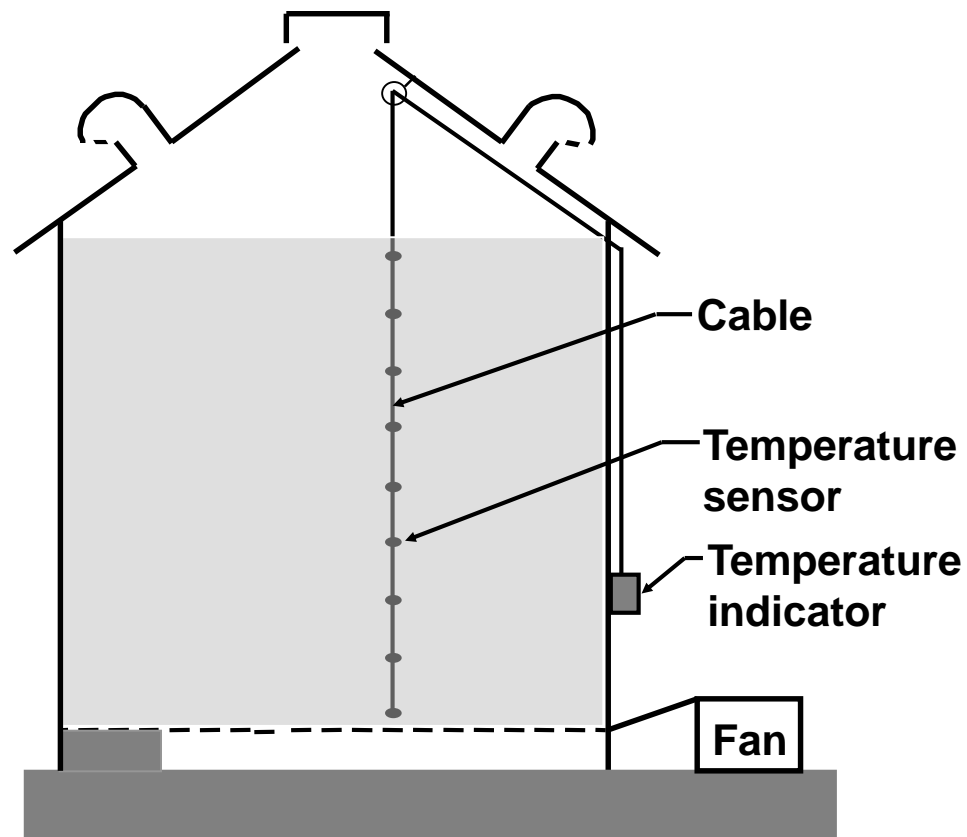
- Temperature
- Moisture
- Insects

Sensors & Fan Controllers



Technology does not replace Management!

Senses only grain near cable



For More Information



**Internet Search: NDSU Grain Drying
and Storage**

EXTENDING KNOWLEDGE >> CHANGING LIVES