

Grain Storage Best Management Practices



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EXTENDING KNOWLEDGE >> CHANGING LIVES

NDSU

EXTENSION

Manage - to direct with a degree of skill



Monitor:

- Temperature
- Moisture
- Insects
- Mold
- Carbon dioxide

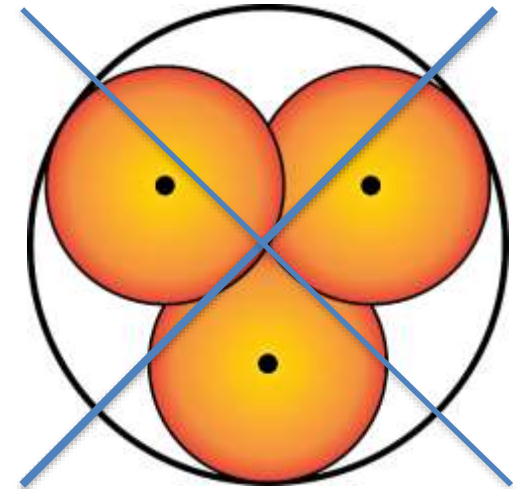
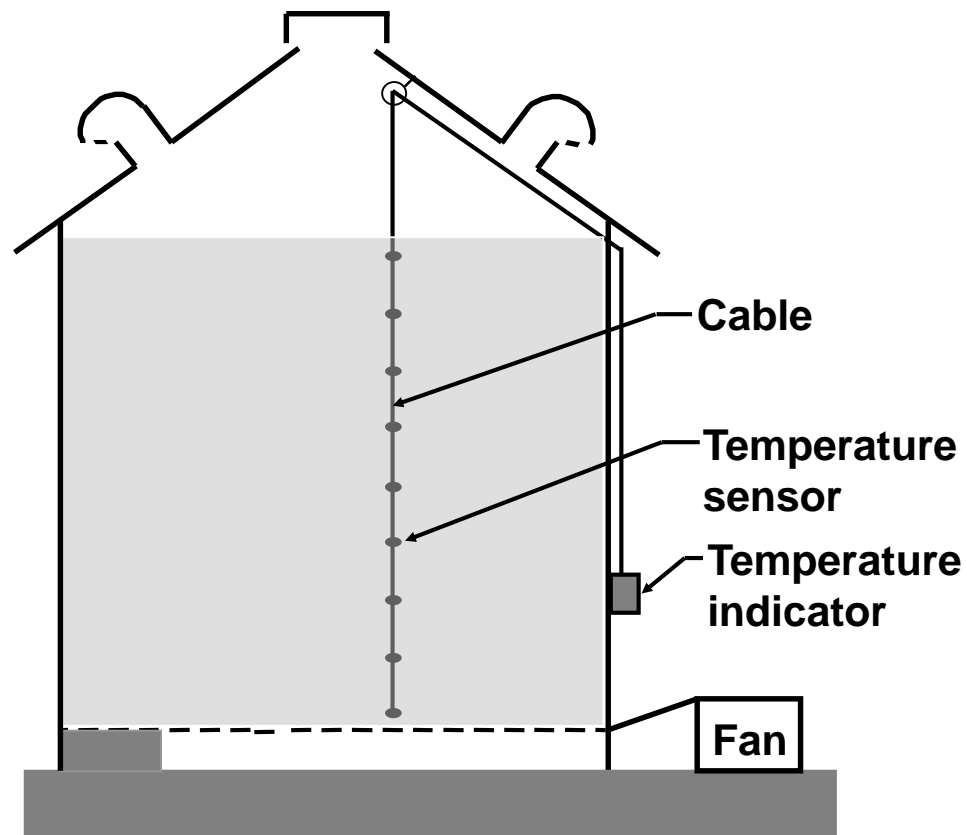
Check Grain Frequently

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

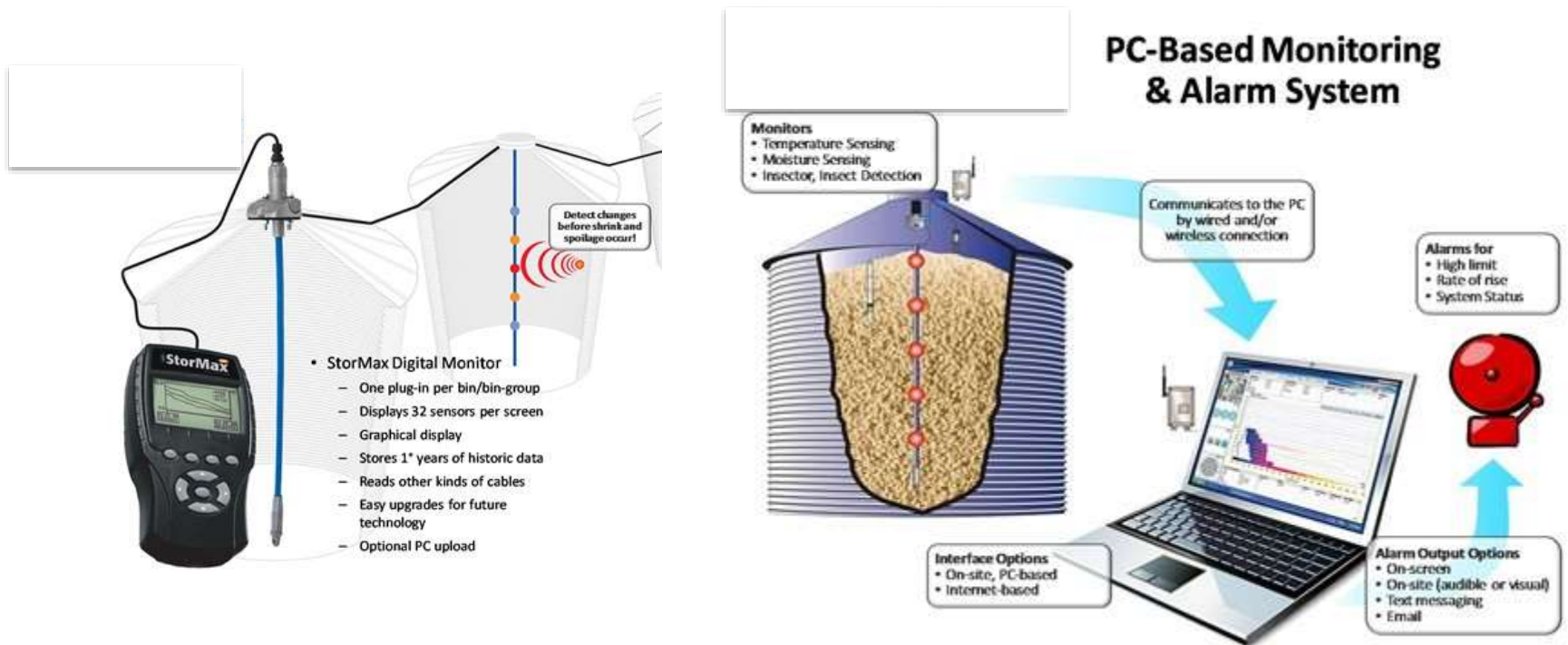
Manage: Aerate & Dry

- Temperature
- Moisture

Senses only grain near cable



Sensors & Fan Controllers



Technology does not replace Management!

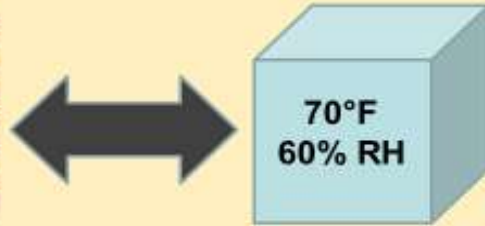
Recommended Long-Term Storage Moisture Content

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%



“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

“Approximate” Allowable Storage Time for Soybeans

Cumulative

* Exceeds 300 days

Moisture Content (%)	--- Grain Temperature (°F) ---					
	30°	40°	50°	60°	70°	80°
	Approximate Allowable Storage Time (Days)					
11	*	*	*	*	200	140
12	*	*	*	240	125	70
13	*	*	230	120	70	40
14	*	280	130	75	45	20
15	*	200	90	50	30	15
16	*	140	70	35	20	10
17	*	90	50	25	14	7
19	190	60	30	15	8	3
21	130	40	15	10	6	2
23	90	35	12	8	5	2
25	70	30	10	7	4	2
27	60	25	5	5	3	1

* Allowable storage time exceeds 300 days

Storability

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



Moisture Measurement



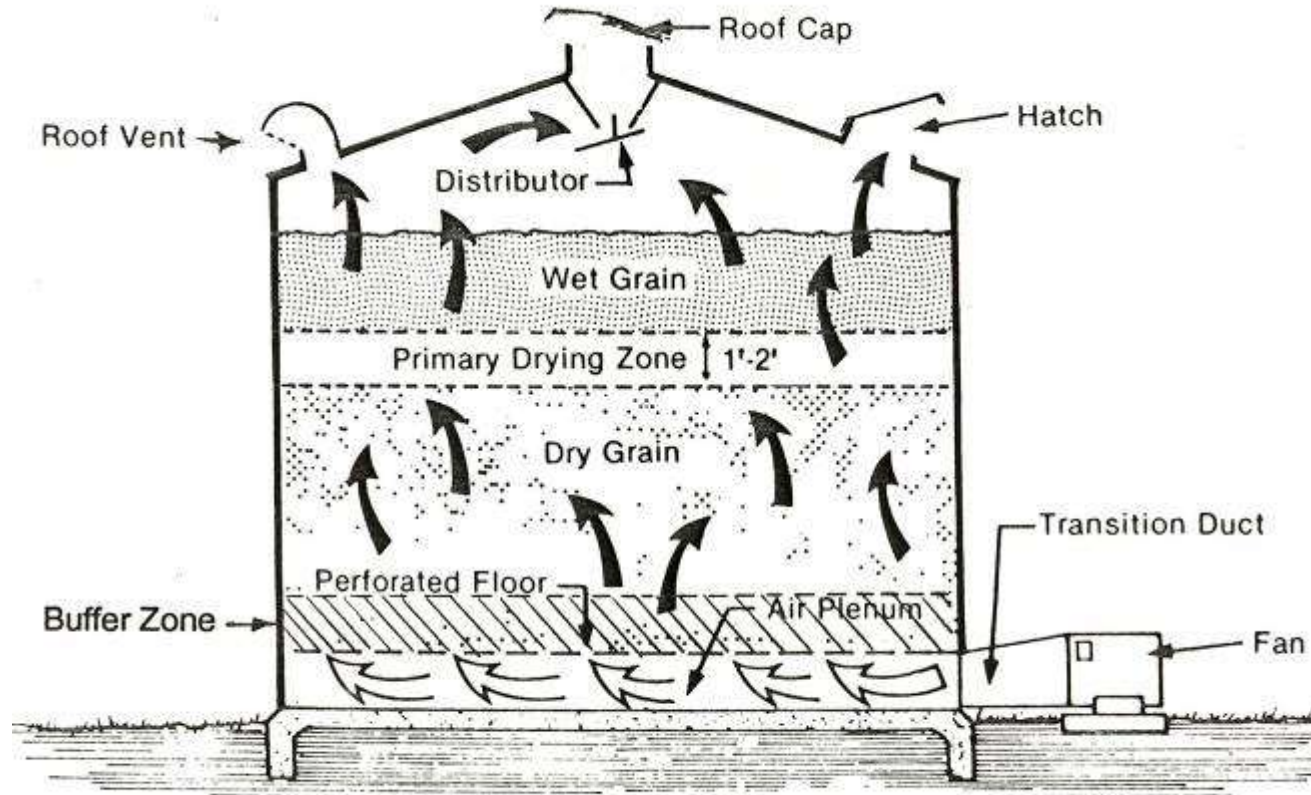
- **Adjust for temperature**
 - **May not be accurate $<40^{\circ}\text{F}$**
- **More sensitive to outside of kernel**
 - **Moisture variation after drying**
 - **Meters affected by condensation**
- **Growing season; foreign material effects**



Recommend:

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

Natural Air Drying



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

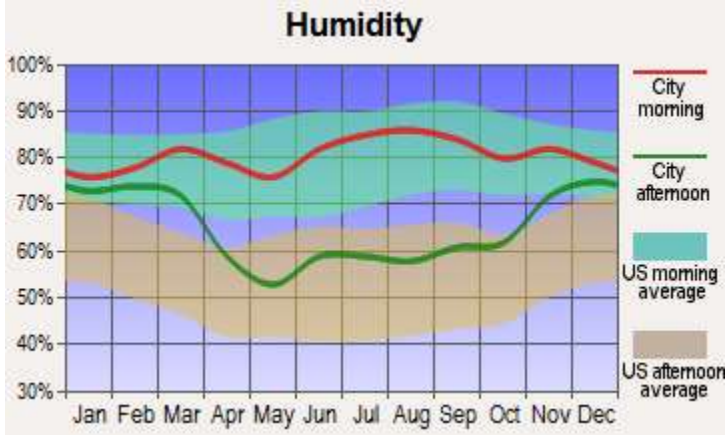
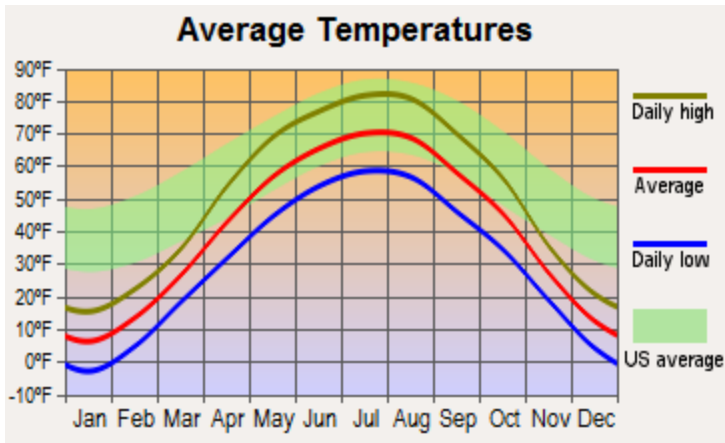
Final Moisture Content \approx 11% Airflow Rate = 1.0 cfm/bu.

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

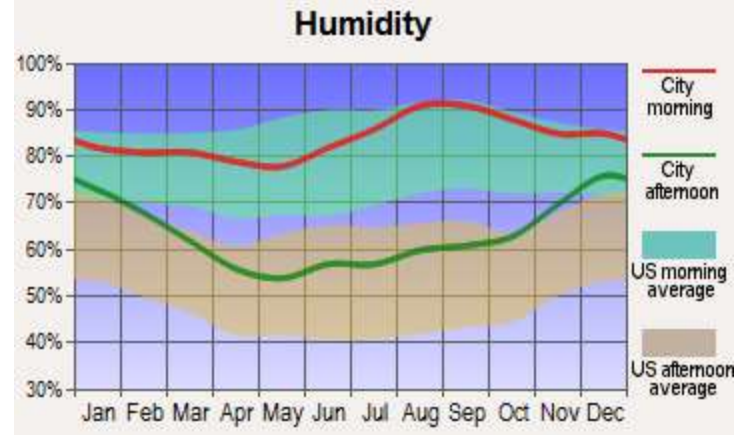
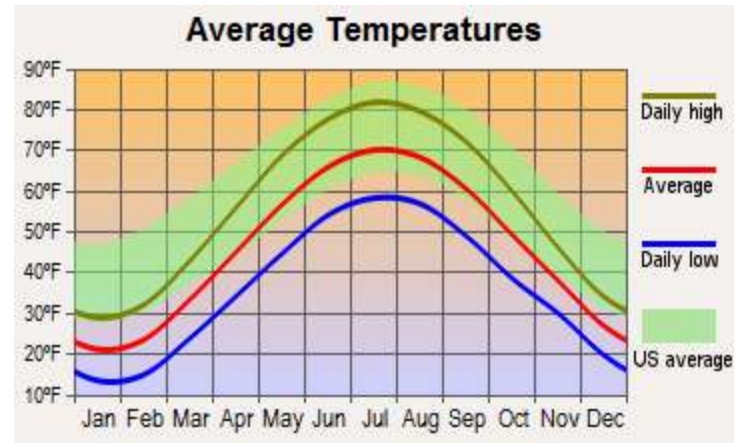
Maximum moisture content for air drying is about 15% to 16% with an airflow rate of at least 1.0 cfm/bu. Start drying when outdoor temperature averages about 40°F.

Temperature and Humidity

Fargo, North Dakota



Lansing, Michigan



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**

Fans Off During Snow/Rain/Fog



High Temperature Drying Soybeans

- Follow dryer recommendations to start then adjust as appropriate
- Typical Maximum Drying Temperature (non-food soybeans)

Continuous flow	120-130° F
Batch Dryer	110° F
Seed	110° F
- Relative humidity above 40% reduces cracks $\approx 20^{\circ}\text{F}$ temperature increase. \approx



Damage Occurring to Soybeans as Function of Drying Temperature

Drying Temperature (°F)	Skins Cracked (%)	Beans Cracked (%)
100	10 - 60	5 - 20
130	50 - 90	20 - 70
160	80 - 100	30 - 80

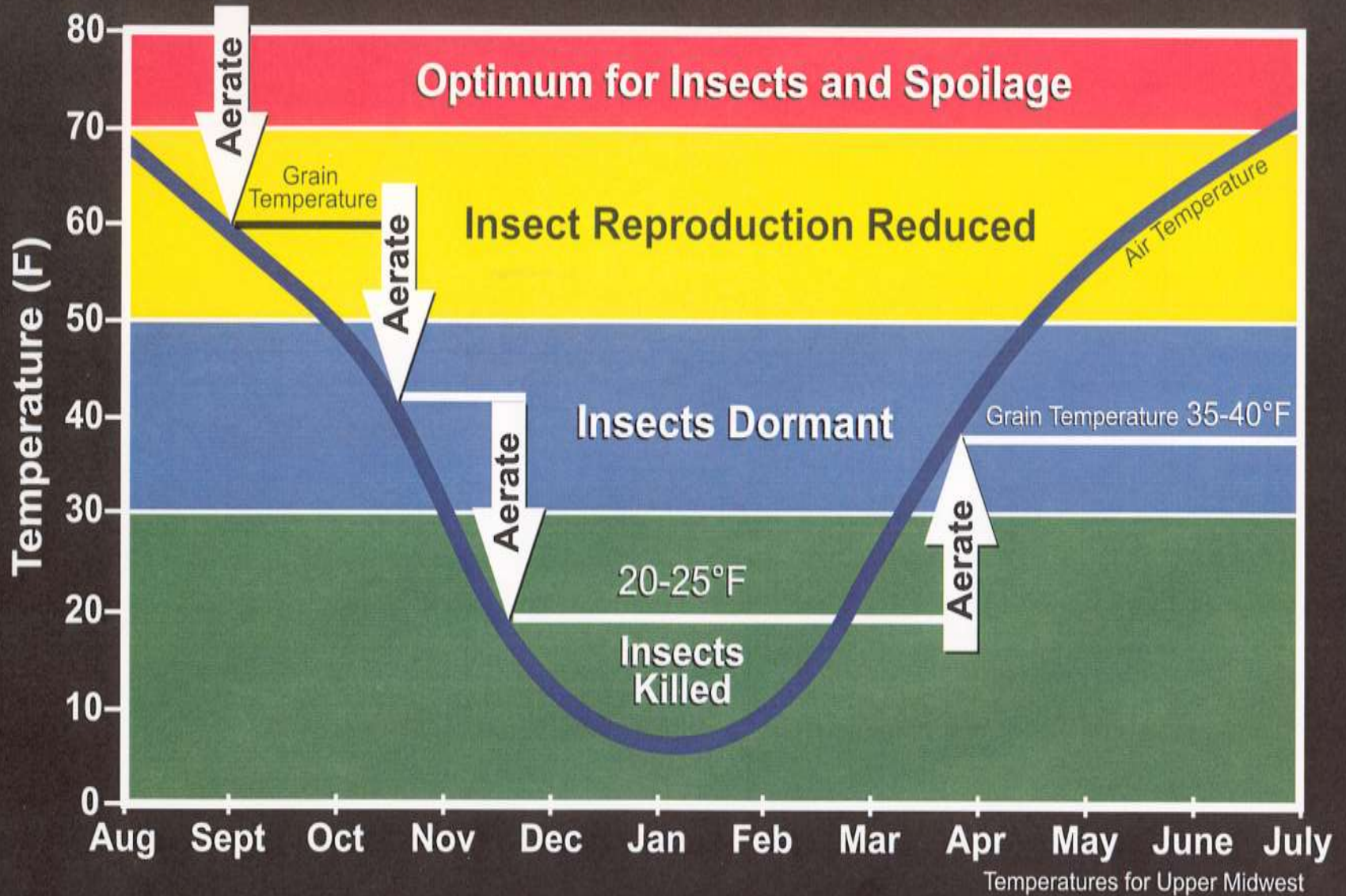


Fire Hazard Drying Soybeans

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



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

Spring Grain Cooling



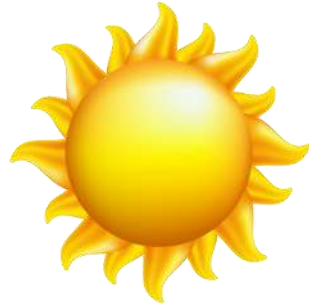
Solar Radiation (Btu/ft²-day)

	<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

Cool Stored Soybeans

- Free fatty acids increase with moisture, temperature, and time
- Storage of 12% beans @ 70 F < 4 months to exceed free fatty acid acceptable level.
- Cool to 20 - 30 F for winter
- Keep as cool as possible spring & summer

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.

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

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EXTENSION

Background Show Background

Settings Print

Bin and Crop Inputs

Select a crop: Barley Bin Diameter, feet: 21
Floor Type: Full Duct 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

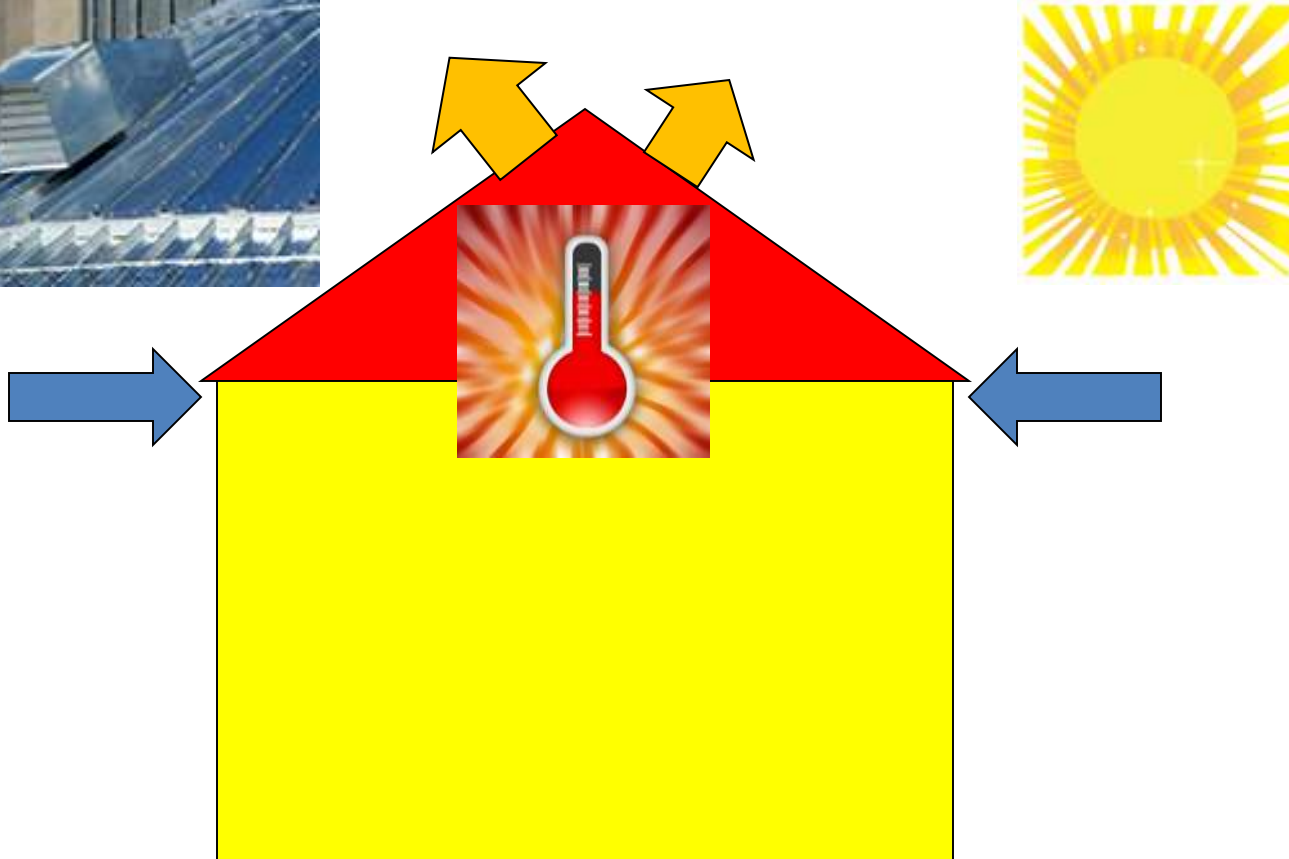
Airflow vs Depth Table Airflow Graph System Graph

Cover Fans When Not Operating



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

Ventilate Bin Headspace



Grain Handling & Storage Safety





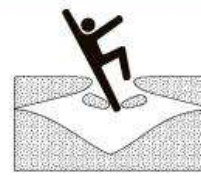
DANGER



Rotating flighting will
kill or dismember.



Flowing material will
trap and suffocate.



Crusted material will
collapse and suffocate.

Keep clear of all augers. DO NOT ENTER this bin!

If you must enter the bin:

1. Shut off and lock out all power.
2. Use a safety harness and safety line.
3. Station another person outside the bin.
4. Avoid the center of the bin.
5. Wear proper breathing equipment or respirator.

Failure to heed these warnings could result in serious injury or death

DC-GBC-1A

2010 Spike Due to Wet Grain

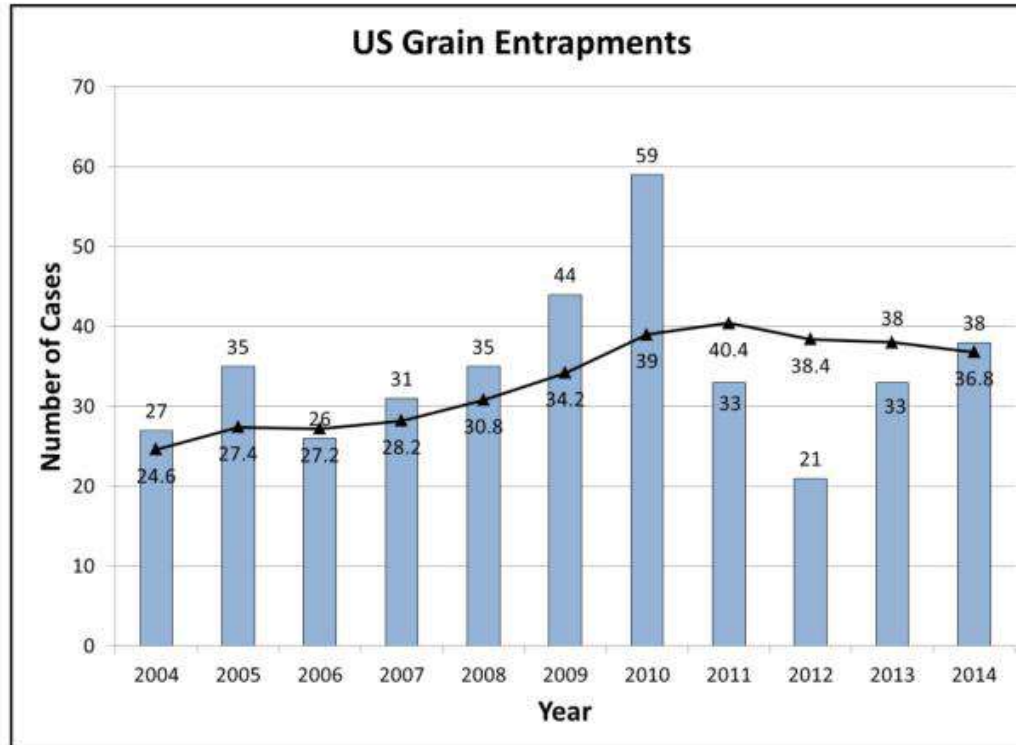


Figure 6: Number of annual grain entrapment cases recorded between 2004 and 2014.

Middle Age Risk

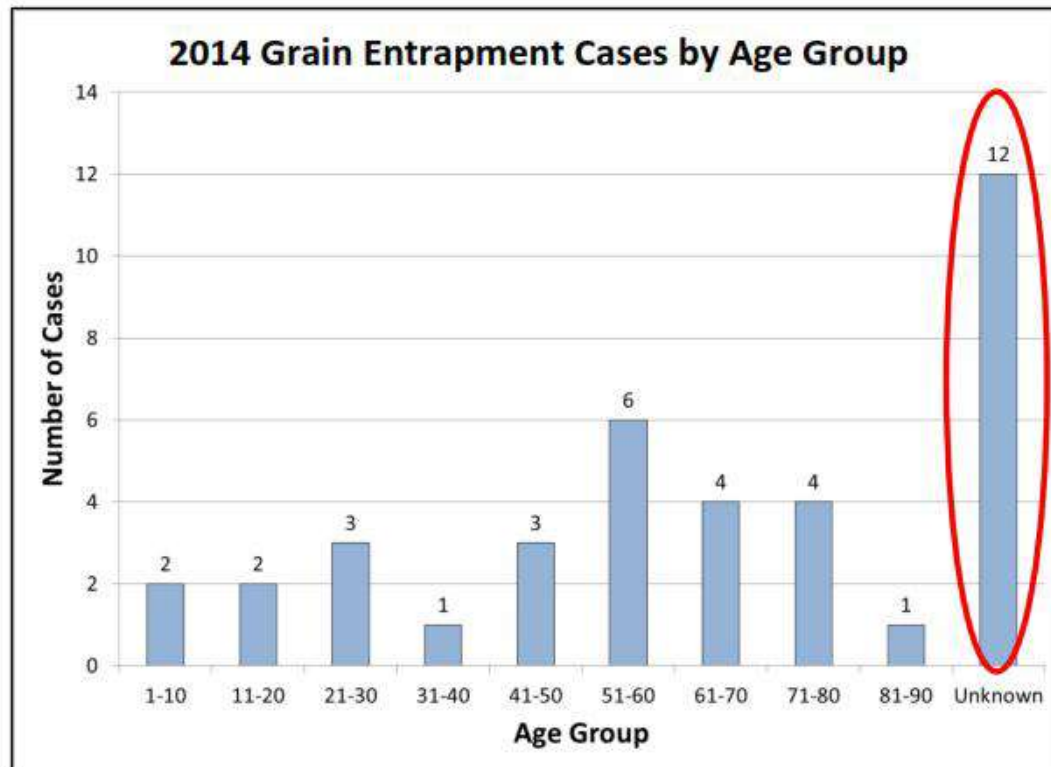
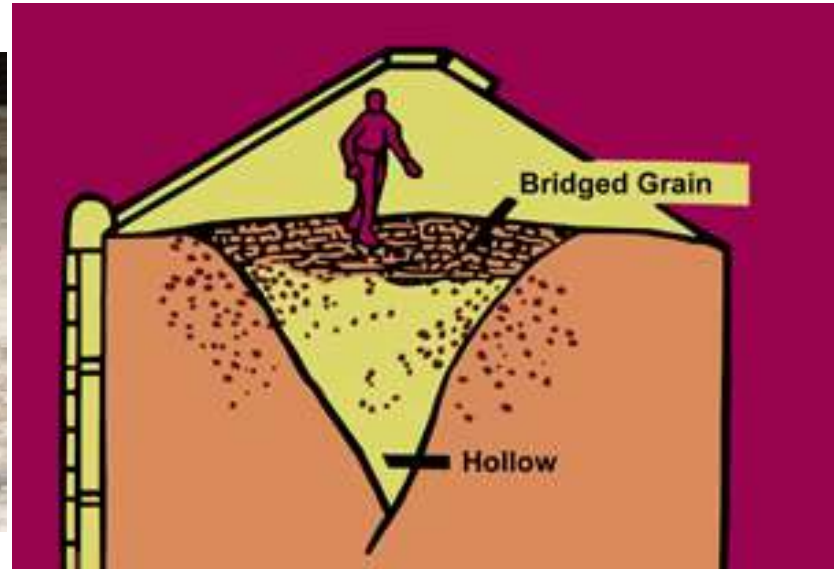
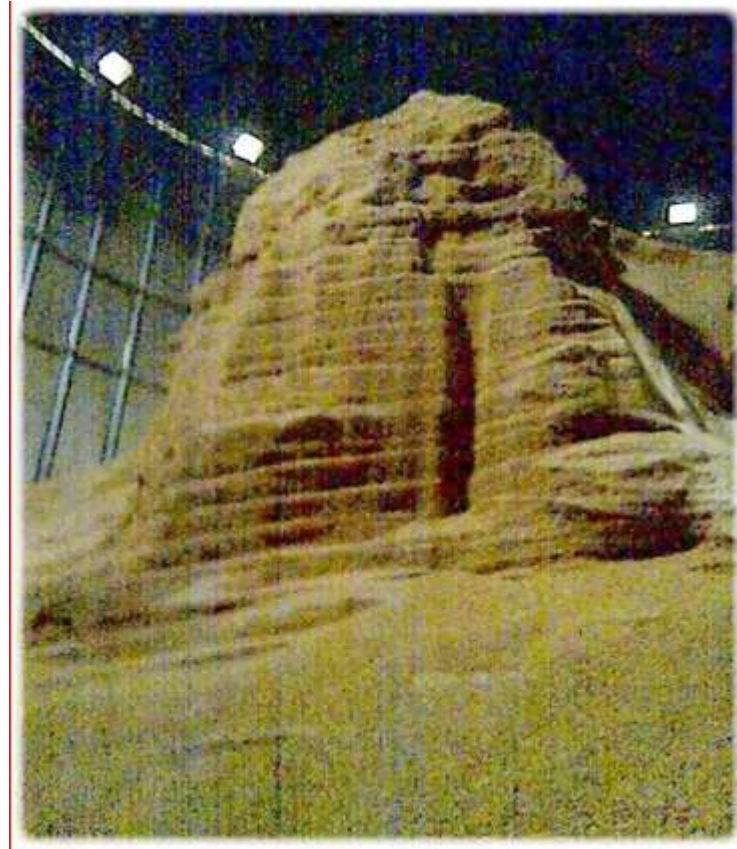


Figure 7: Age distribution of 2014 grain entrapment victims by number of cases recorded.

Bridging



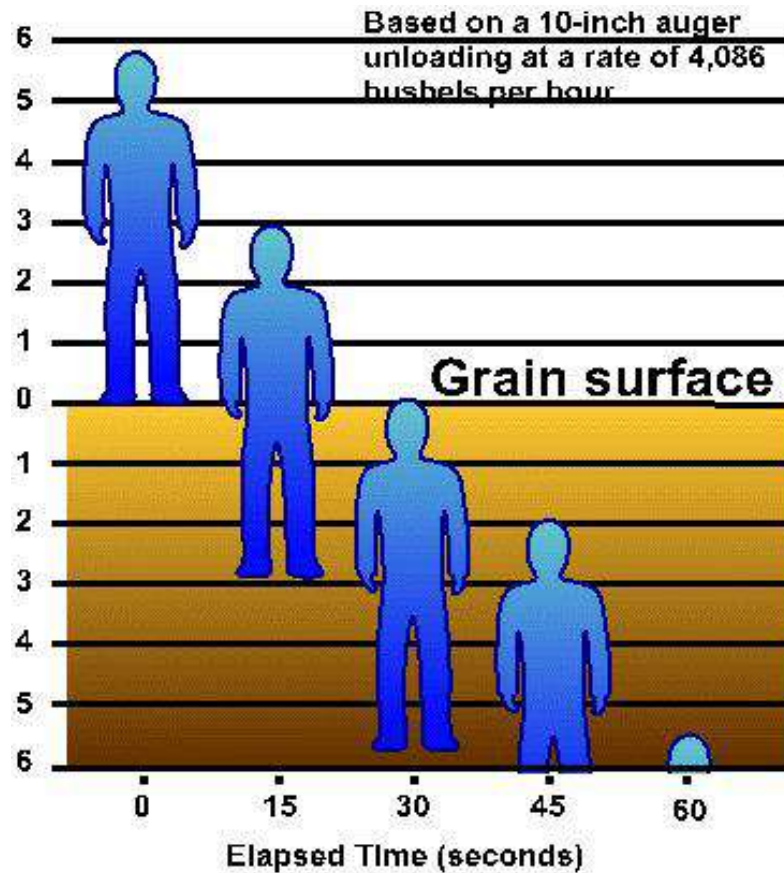
Grain Columns



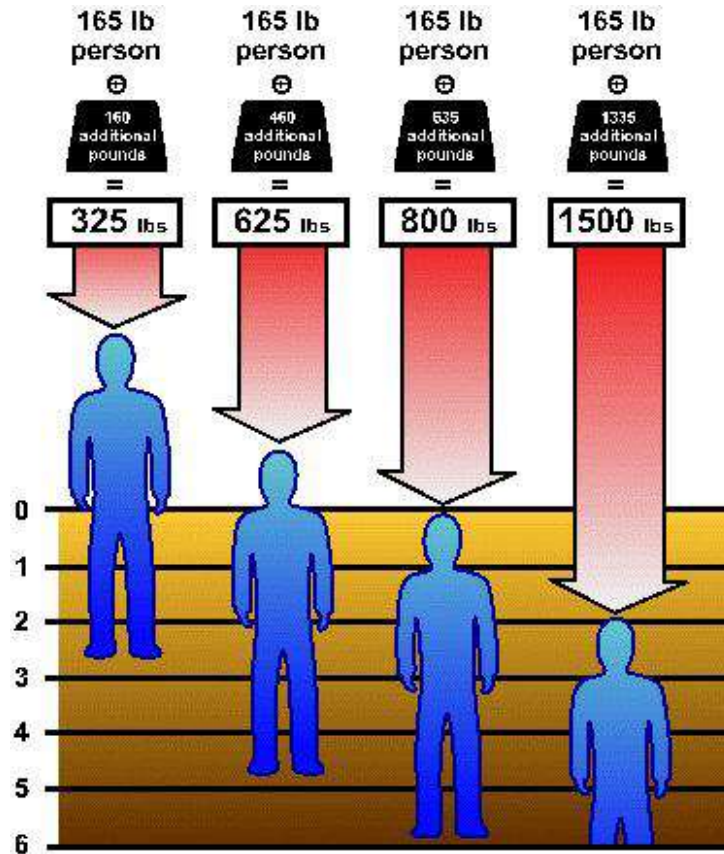
#1 Cause – Rodding With Unload Conveyor Running



Speed of Entrapment



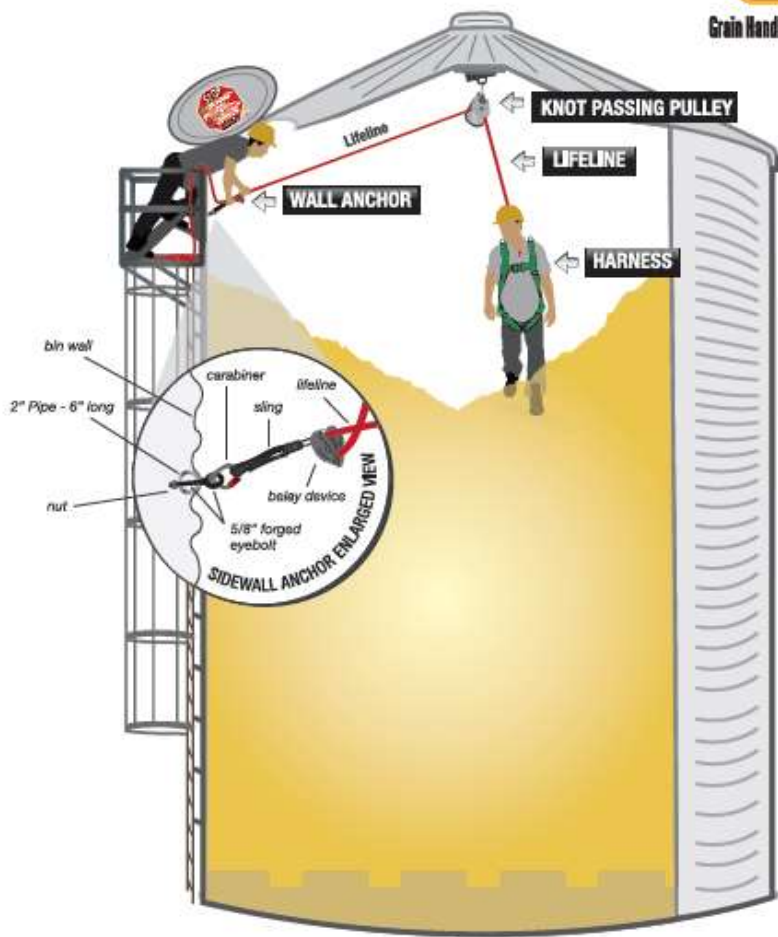
Cannot Pull Out!



Lifeline System Set-up



Grain Handling Safety Condition



A sidewall anchor is NEVER attached to any part of the inside bin ladder.
The inside bin ladder was omitted from this drawing for illustrative purposes.

www.grainsafety.org

Note: Figures above are for detailed reference ONLY and are NOT drawn to scale.
The bin access ladder, cage, platform, roof and other structural elements are for illustrative purposes ONLY and as drawn may not comply fully with OSHA standards or have detail.

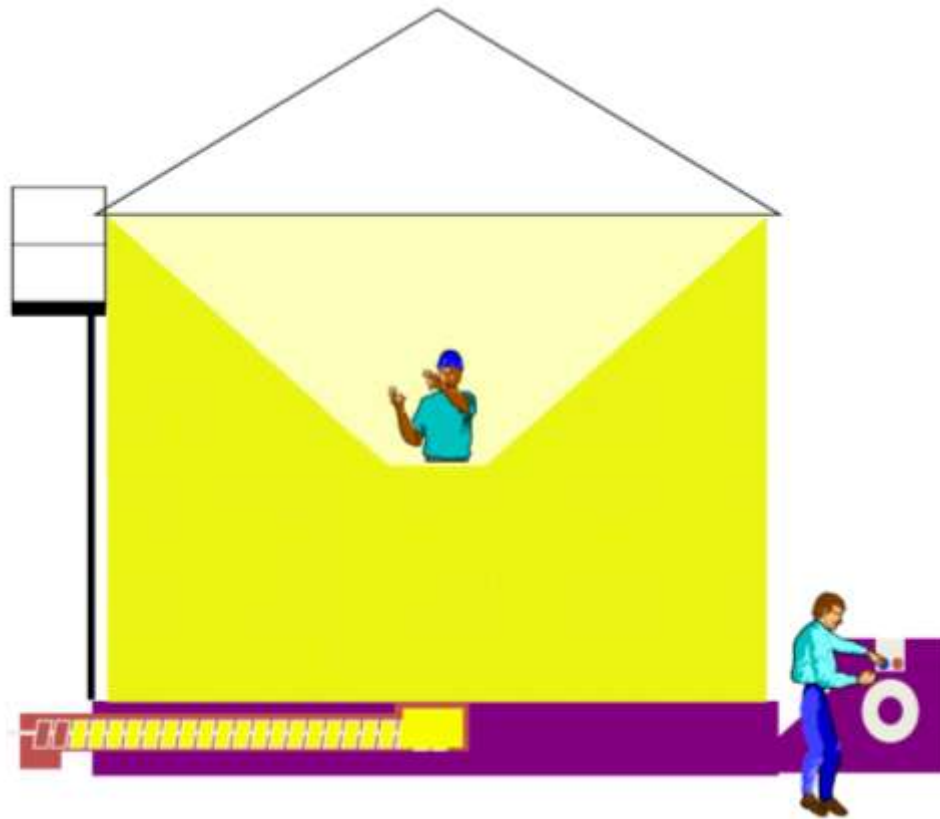
Grain Engulfment Prevention System



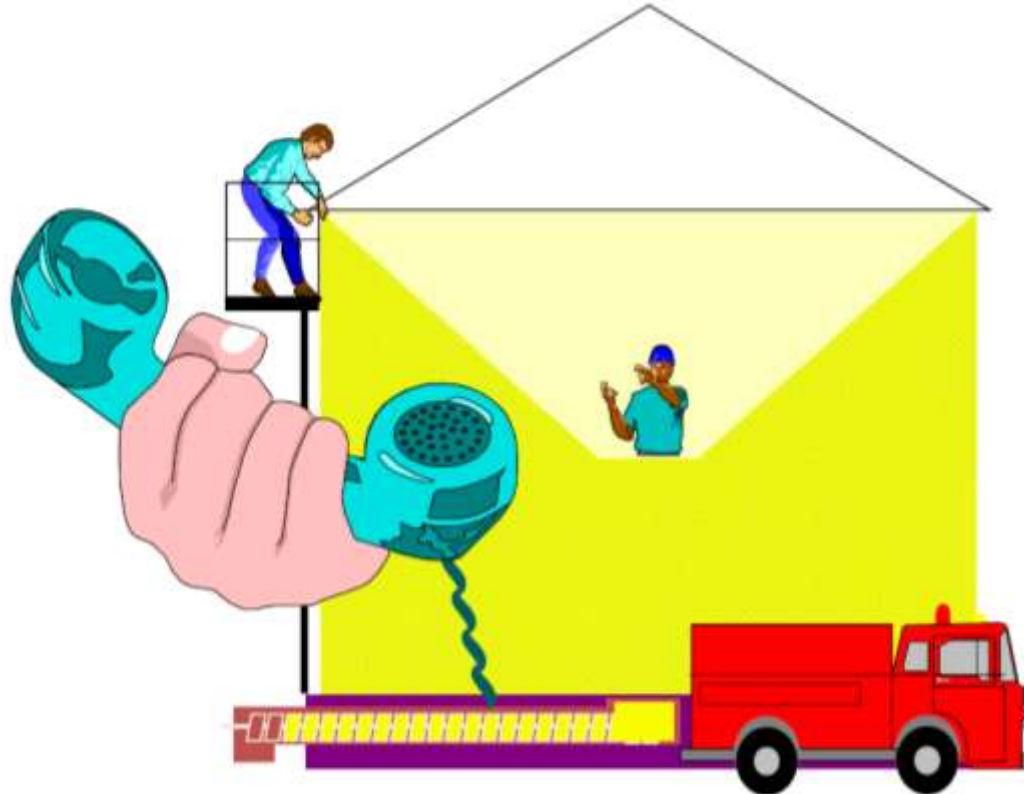
Lockout / Tagout – IS A MUST!



Start Aeration

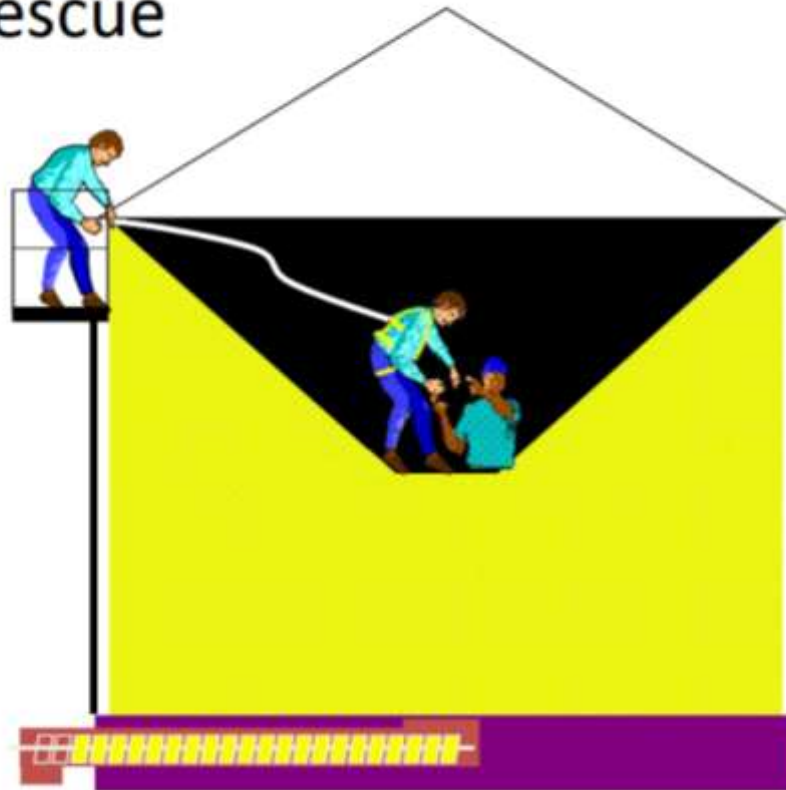


Call for Help!



What happens when enter bin?

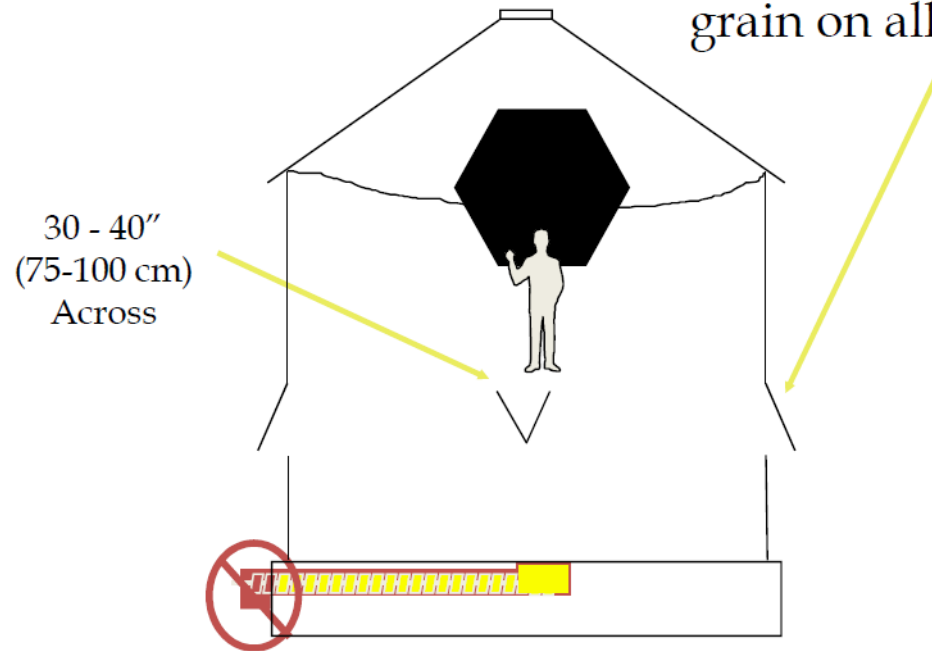
Rescue



Remove Grain

Rescue

Cut holes at equal distance around the bin, below the victim, to release the grain on all sides.



Rescue Tube

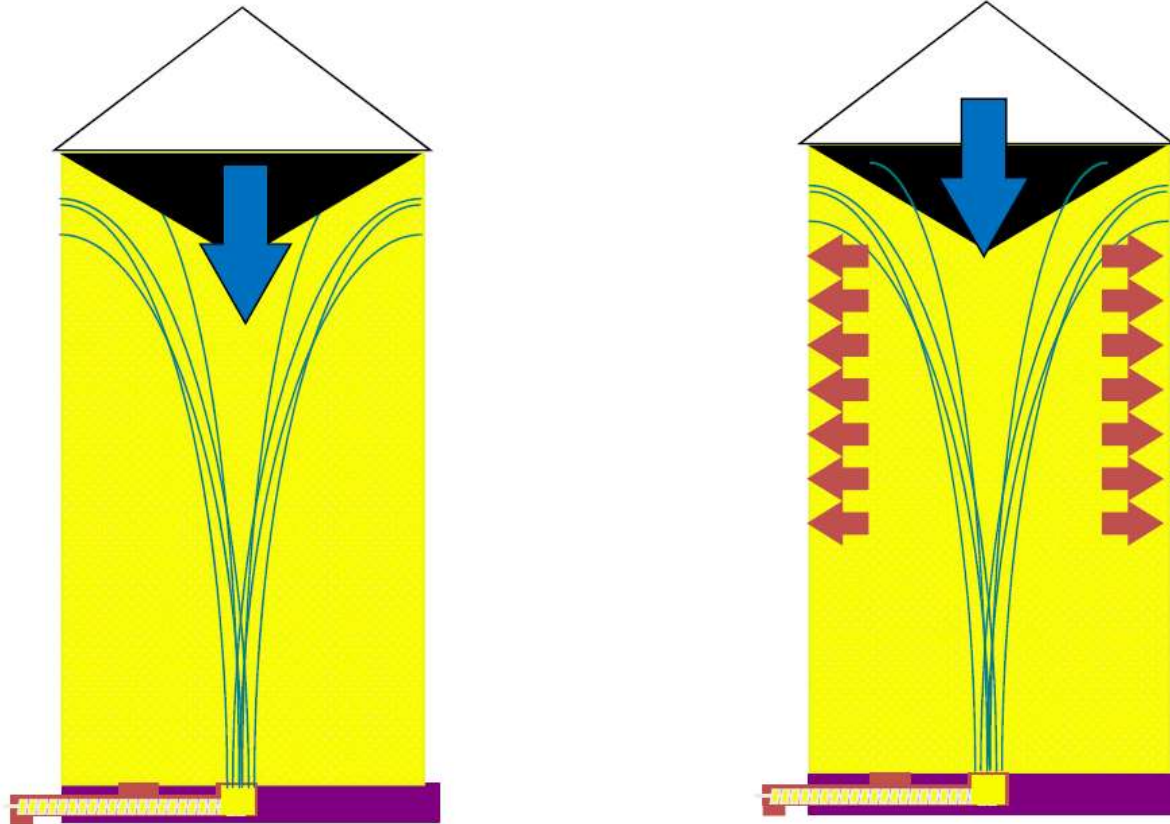


Waterproof Bag:
Handles on sides and ends for ease of carrying

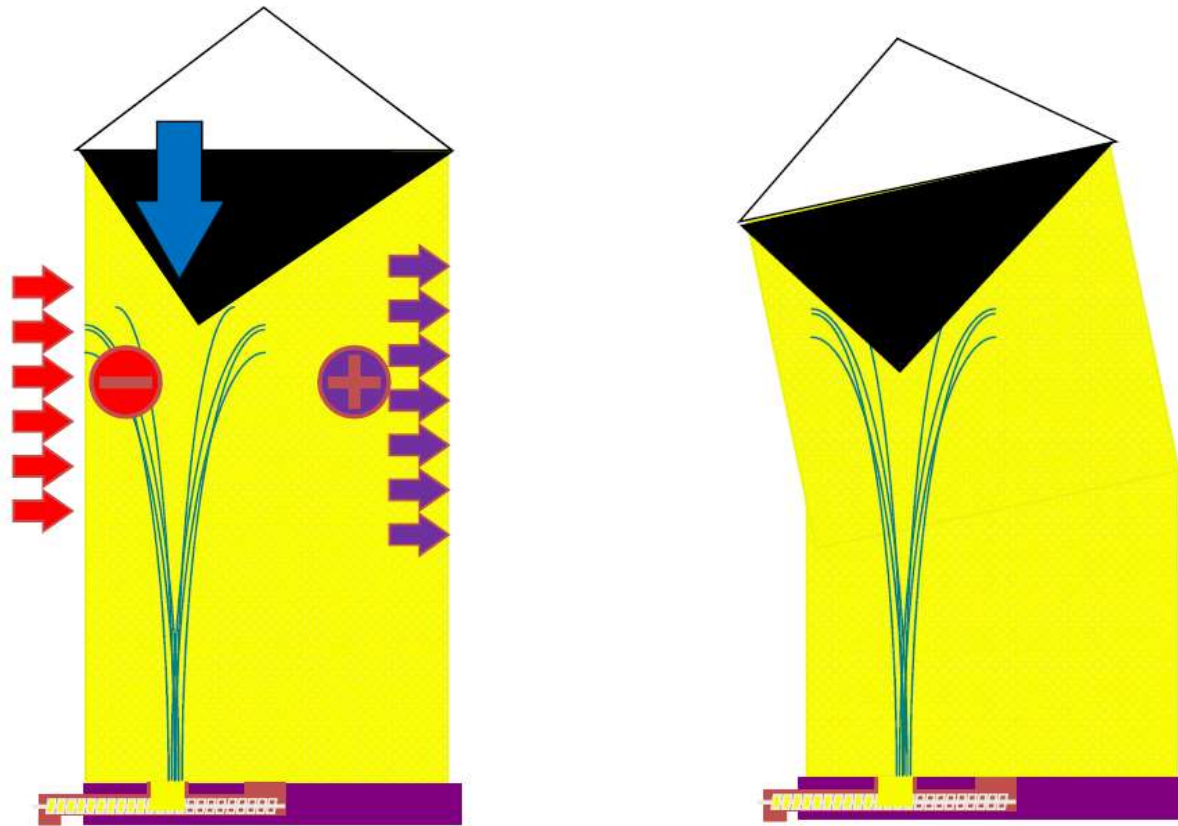


Rescue Tube

Silo Unloading - Center First



Off Center Unloading



Bin Collapsing



Bin Sweeps

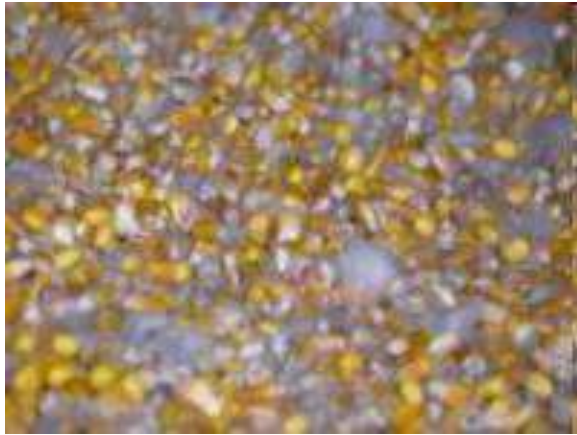


Grain Dust Hazard

Exposure to grain dust produces asthma, other respiratory effects (e.g., cough, rhinitis, and farmers lung), and nonpulmonary disorders (e.g., conjunctivitis, grain fever, and dermatitis). Though thorough characterization of allergenicity (Type I, IgE-mediated) is lacking, occupational exposure to grain dust has clearly been associated with potent systemic immunologic responses that evoke inflammatory responses of smooth muscle in the airways.



Moldy Grain Health Hazard



Fall Hazards



For More Information



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

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