

# ***Aeration Management: Key to Grain Quality and Safety***



*Working Together To Keep Grain In Condition  
and Workers Safe*



**AGRICULTURE**

Carol Jones, PhD., PE  
Stored Product Engineering  
Biosystems and Ag. Engr. Dept.

## **Objective for Storage:**

To maintain quality of stored products  
after harvest and before the end  
use...on the dinner table!

## **Dilemma of Storage:**

Quality NEVER improves during  
storage!

# ***Why do we use aeration?***

## **Prevent Mold, Insects, Grain Deterioration**

- Maintain uniform temperatures, moisture accumulation, condensation
- Keep temperatures as low as feasible
- Aerate grain after a fumigation

***Aeration is a part of a bigger system***

# ***News Flash: Employee***

***“fell into a grain bin” ...Really????!!!!***

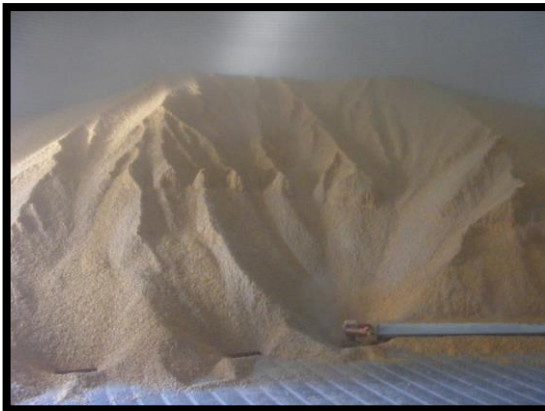


What really happens:

- Grain won't come out of the bin
- Material stuck on walls
- Bridge breakthrough
- Walking down grain with auger running



## ***When does it happen?***



- Cleaning out a bin
- Breaking up chunks for reclaim system
- Dislodging bridges or walls of grain
- Moving a stuck sweep auger
- Fumigation, top dressing
- Equipment/structural repairs

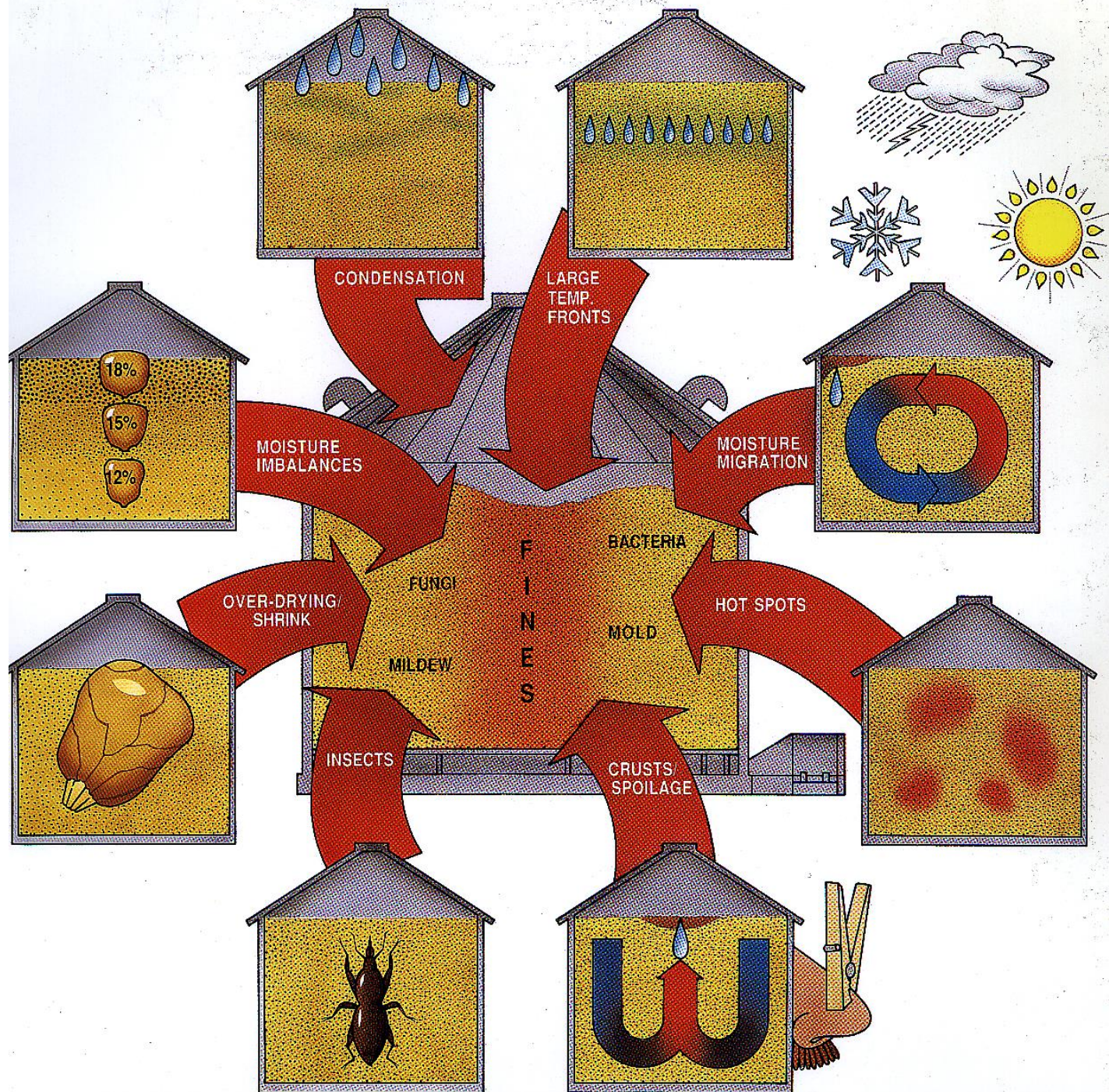


# Moldy Grain = Unsafe Working Conditions



[http://jonermining.co.za/  
wp-content/uploads/2016/06/silo.png](http://jonermining.co.za/wp-content/uploads/2016/06/silo.png)





# Mold/fungus/mycotoxins ...

## >60% RH, >60F and >16% MC

Fungal species	Mycotoxin produced	Moisture content (%) for mycotoxin production	Moisture content (%) for fungal growth
<i>Aspergillus flavus</i>	Aflatoxin B1	17.6-19	19.2
<i>Aspergillus parasiticus</i>	Aflatoxin B1	19	20.2
<i>Aspergillus ochraceus</i>	Ochratoxin A	16.5	19.6
<i>Penicillium patulum</i>	Patulin	18	27
<i>Penicillium exapansum</i>	Patulin	18.3-19	30
<i>Penicillium aurantiogriseum</i>	Ochratoxin A	18.5-19.6	20.2-22.0
<i>Penicillium verrucosum</i>	Ochratoxin A	18	18.8-19.8
<i>Fusarium proliferatum</i>	Fumonisin B1	20.5	25
<i>Fusarium verticilliodes</i>	Fumonisin B1	20.5	25

Summarized from Magan et al 2003.

### Two kinds of molds

- Field molds
- Storage molds
- Presence of inoculum on the grain coming into the bin
- Initial grain moisture content and moisture throughout storage
- Weed seed, broken seed, plant debris, insects/rodents
- Storage temperature
- Storage length
- Leaky structures
- Poor aeration/drying management



**Table 2. Safe Storage Period for Soybeans (Days).**

<b>Soybean Temperature (°F)</b>	<b>Soybean Moisture Content (% Wet Basis)</b>									
	<b>10</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>18</b>	<b>20</b>	<b>22</b>
<b>90</b>	>365	>365	251	49	27	16	10	5	4	3
<b>85</b>	>365	>365	336	66	36	21	14	7	5	3
<b>80</b>	>365	>365	>365	87	47	28	18	9	6	4
<b>75</b>	>365	>365	>365	117	63	38	24	12	8	5
<b>70</b>	>365	>365	>365	157	85	50	32	16	10	7
<b>65</b>	>365	>365	>365	210	113	67	43	22	13	9
<b>60</b>	>365	>365	>365	278	150	89	57	28	17	11
<b>55</b>	>365	>365	>365	>365	226	134	86	38	22	14
<b>50</b>	>365	>365	>365	>365	339	202	130	50	29	19
<b>45</b>	>365	>365	>365	>365	>365	303	195	66	37	24
<b>40</b>	>365	>365	>365	>365	>365	>365	293	88	48	30
<b>35</b>	>365	>365	>365	>365	>365	>365	>365	115	62	39

\*It should be mentioned that these values assumed about 0.5% dry matter loss.

# Use all of our tools to keep grain in good condition (**and safer**)

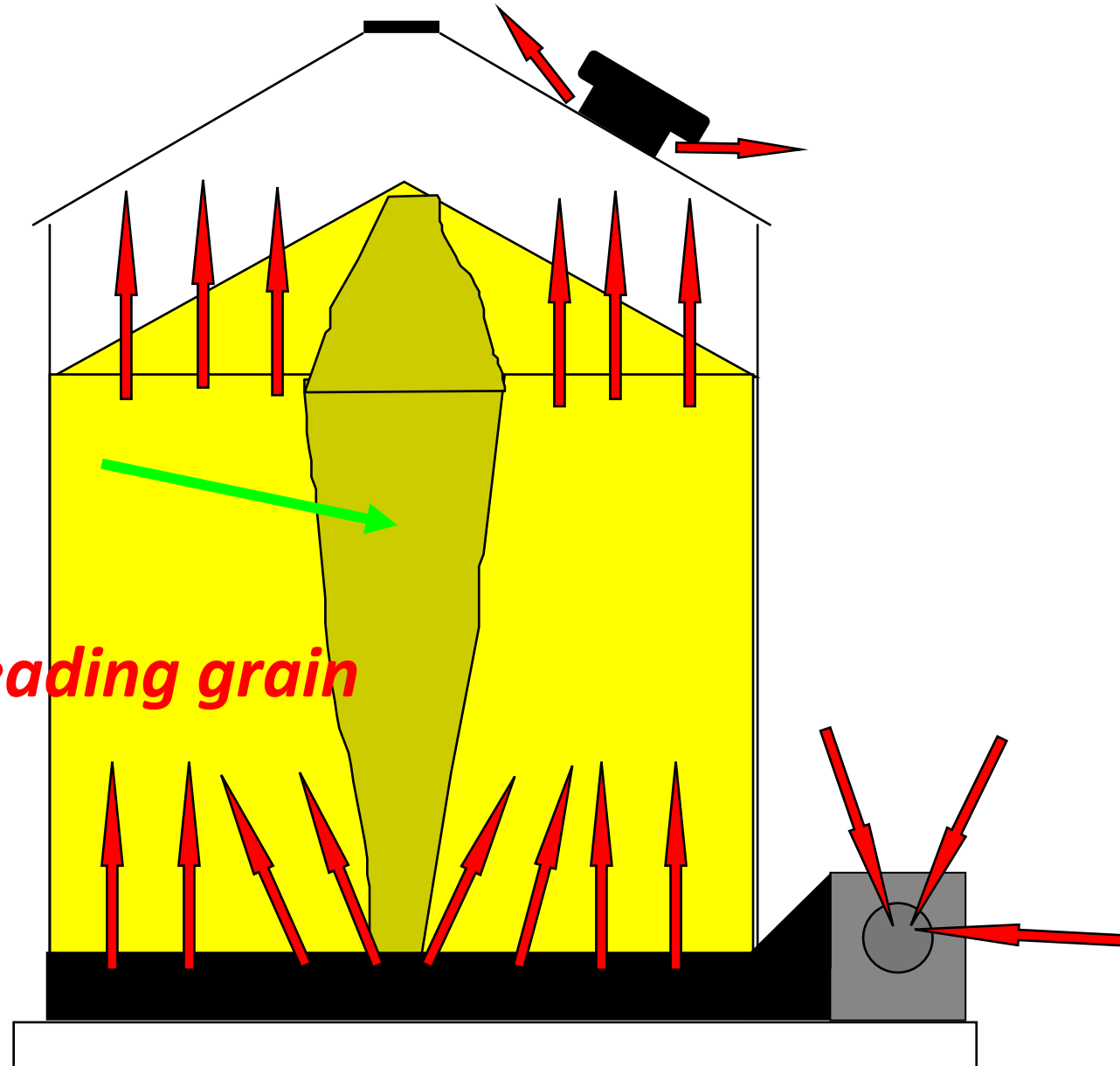
- Clean Grain, Bins and Equipment
- Seal/Repair bins
- Empty bin treatments
- Load grain carefully
- Fumigate when necessary and appropriate
- ***Manage aeration***
- ***Monitor for problems***

Core of fines

Foreign Material  
(FM)

Broken grain

Weed seeds



***Solution:***

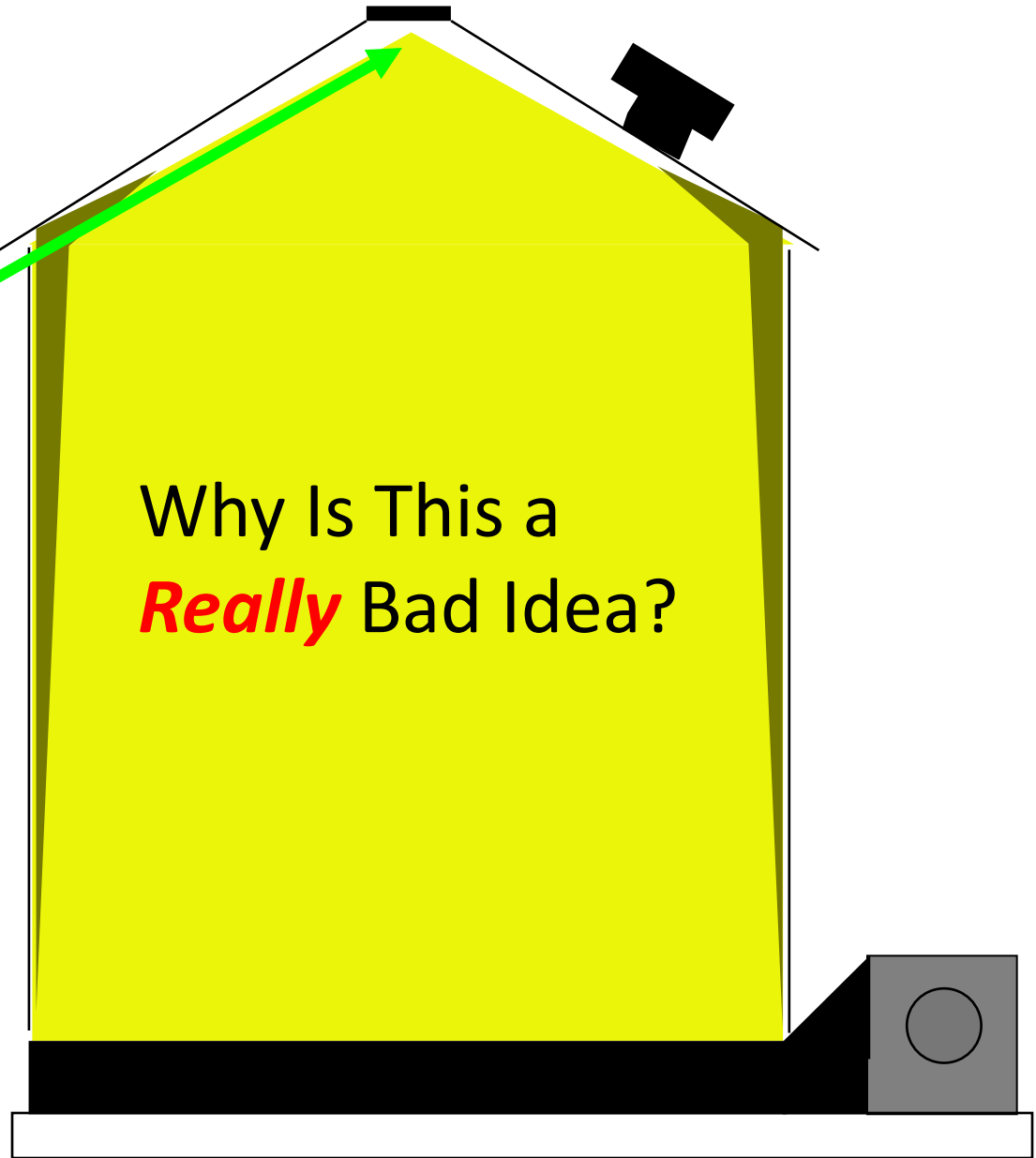
***Coring or spreading grain***



- Over-Filling

- Poor head space ventilation
- Spoiled grain on silo wall
- Impossible to monitor grain surface

Why Is This a  
*Really* Bad Idea?



# Headspace Condensation

- Caused by temperature differences between grain and outside air.

*15F temperature difference = condensation*

- Use **power exhaust fans** and aeration system to move moisture out and equalize temperatures

**CAUTION:** Vents MUST be sized for aeration system and must be open.





# When to Run Fans???

*Generally:*

- Uniformly cool all the grain in the bin (depends on fan size...usually 150 hours for 0.1 cfm/bu)
- Aerate as soon as possible during and after binning.  
Reduce temps to less than 60F or as cool as possible
- In late fall, run fans for a week to get grain as cool as possible.
- Use fans to remove odors occasionally
- Cover fans when not in use.
- Understand *Equilibrium Moisture Content*

# EMC...What's it all about?

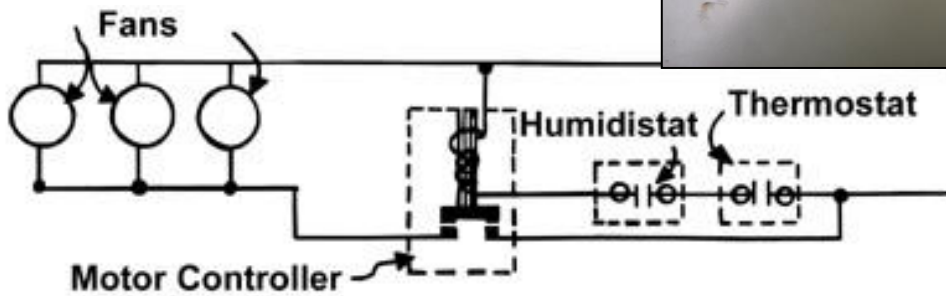
		Soybean Equilibrium Moisture Content																		
		Relative Humidity (%)																		
		5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
Temperature (°F)	20	1.2	2.2	3.1	4.0	4.9	5.8	6.7	7.7	8.6	9.6	10.7	11.8	13.1	14.4	15.9	17.6	19.6	22.3	26.2
	25	1.2	2.2	3.1	4.0	4.8	5.7	6.6	7.5	8.5	9.5	10.5	11.6	12.9	14.2	15.6	17.3	19.3	22.0	25.9
	30	1.2	2.1	3.0	3.9	4.8	5.6	6.5	7.4	8.4	9.3	10.4	11.5	12.7	14.0	15.4	17.1	19.1	21.7	25.5
	35	1.2	2.1	3.0	3.8	4.7	5.5	6.4	7.3	8.2	9.2	10.2	11.3	12.5	13.8	15.2	16.8	18.8	21.4	25.2
	40	1.2	2.1	2.9	3.8	4.6	5.5	6.3	7.2	8.1	9.1	10.1	11.1	12.3	13.6	15.0	16.6	18.6	21.1	24.9
	45	1.1	2.0	2.9	3.7	4.5	5.4	6.2	7.1	8.0	8.9	9.9	11.0	12.1	13.4	14.8	16.4	18.3	20.8	24.6
	50	1.1	2.0	2.8	3.7	4.5	5.3	6.1	7.0	7.9	8.8	9.8	10.8	11.9	13.2	14.6	16.2	18.1	20.6	24.3
	55	1.1	2.0	2.8	3.6	4.4	5.2	6.0	6.9	7.8	8.7	9.6	10.7	11.8	13.0	14.4	16.0	17.8	20.3	24.0
	60	1.1	1.9	2.8	3.6	4.3	5.1	5.9	6.8	7.6	8.6	9.5	10.5	11.6	12.8	14.2	15.7	17.6	20.1	23.7
	65	1.1	1.9	2.7	3.5	4.3	5.1	5.9	6.7	7.5	8.4	9.4	10.4	11.5	12.7	14.0	15.5	17.4	19.8	23.5
	70	1.1	1.9	2.7	3.5	4.2	5.0	5.8	6.6	7.4	8.3	9.3	10.2	11.3	12.5	13.8	15.4	17.2	19.6	23.2
	75	1.0	1.9	2.6	3.4	4.2	4.9	5.7	6.5	7.3	8.2	9.1	10.1	11.2	12.3	13.7	15.2	17.0	19.3	23.0
	80	1.0	1.8	2.6	3.4	4.1	4.9	5.6	6.4	7.2	8.1	9.0	10.0	11.0	12.2	13.5	15.0	16.8	19.1	22.7
	85	1.0	1.8	2.6	3.3	4.0	4.8	5.6	6.3	7.1	8.0	8.9	9.9	10.9	12.0	13.2	14.8	16.6	18.9	22.5
	90	1.0	1.8	2.5	3.3	4.0	4.7	5.5	6.3	7.1	7.9	8.7	9.6	10.6	11.7	12.9	14.5	16.2	18.5	22.0
	95	1.0	1.8	2.5	3.2	3.9	4.7	5.4	6.2	7.0	7.8	8.7	9.6	10.6	11.7	13.0	14.5	16.2	18.5	22.0
	100	1.0	1.7	2.5	3.2	3.9	4.6	5.3	6.1	6.9	7.7	8.6	9.5	10.5	11.6	12.9	14.3	16.0	18.3	21.7

Other charts available at:

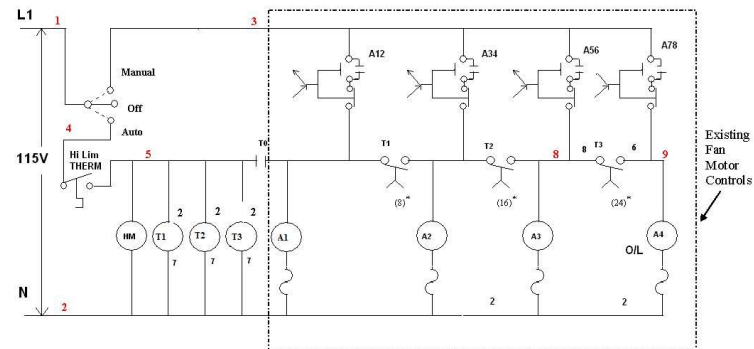
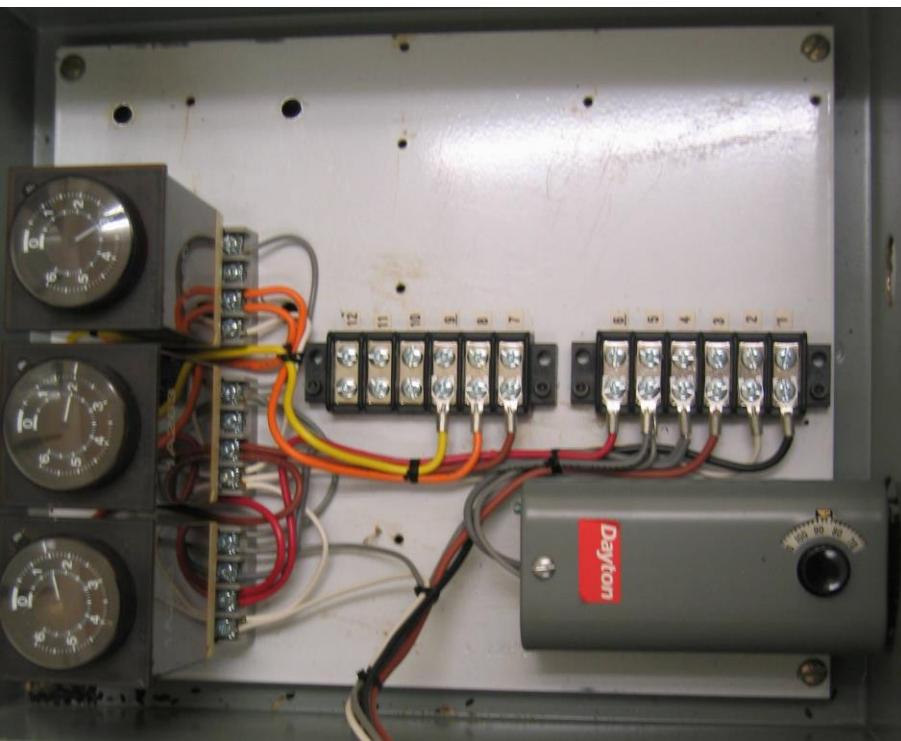
<https://www.ag.ndsu.edu/graindrying/documents/GrainEquilibriumMoistureContentCharts.pdf>



## Temperature and Insect Fan Control System







Tx: Time delay relays  
 Ax: Aeration Fan Motor Starter Coils (#1- #8: auxiliary sw. contacts)  
 L1: Control circuit power wire-115V (Red)  
 N: Neutral circuit wire (white)  
 #1- #8: Terminal Strip  
 P/P: Pull/Push Switch  
 Hi Lim THERM: Line Voltage Thermostat  
 O/L: Overload relay on motor starter  
 Auto/Manual: Automatic/ Manual positions of the switch  
 \* Numbers in (8) are recommended timer settings in seconds. This provides 8 second delays between startup of group of fans

## Aeration Controller

### Parts List

Serial Number	Part Name	Number	Model Number	Manufacturer
1	Enclosure (12' x 10' x 5' )	1	A1210CH	Hoffman Enclosures Inc
2	Line Voltage Thermostat	1	2E206	Dayton Mfg.
3	Socket Relay Base	3	5X852F	Dayton Mfg.
4	Time Delay Relays	3	1A263	Schneider Electric
5	Hour Meter Coil	1	20017	Hobbs AC Hour Meter
6	20 Amp Toggle Switch (SPDT)	1	91-0001	McGill Electrical Product Group
7	6-pole Terminal Strips	2	6YH65	Grainger

# ***Monitoring: Communication with your grain***

Why monitor?

➔ *You can't manage what you don't know about.*

*The Fix is cheaper than the consequences.*

- *Temperature Cables (some have “MC” sensors)*
- *Physically Observing*
- *Sampling*
- *How about insects?*

# ***Monitoring***

**Molds** = Clumps, Big Danger And Less Money!!!

**Temperature:** Cables or Fan Exhaust Air

No Cables? Takes about 150 hours to cool an entire bin to outside air temperatures.

**Moisture:** Sampling, Cables, Smell, Sight, and Hotspots

**CO<sub>2</sub> Monitoring:** Early warning sign of biological activity

***Caution: High moisture loads don't blend by themselves.***

## ***How “Much” air is needed?***

- Steel Bins:  $1/10^{\text{th}}$  cfm/bushel at least
- Concrete Silos and Flat Storage:  $1/20^{\text{th}}$  cfm/bushel at least

### **Tip:**

***More air = faster cooling to prevent mold development.***

***$1/5^{\text{th}}$  cfm/bu = 75 hrs for uniform temperature***



# Goals:

## *Quality Product and Safe Employees*

### **Good Grain Condition Management**

- Condition going in the bin
- **Aeration management**
- **Monitoring**
  - **Temperature Cables**
  - **Air Quality Monitors**
- Recordkeeping
- Marketing poor quality quickly
- Fumigate when needed

### **Training...are we doing it right?**

- Do employees know what to look for?
- Do they understand why they need to monitor or be observant?
- Do they understand the need to report problems?
- Do they understand how to be safe?
- Do they understand what happens when they violate safety rules?

# “New” Equipment/Techniques

## **Fixing Problems from Outside**

- Fumigating when appropriate
- Break up chunks
- Dislodge stuck grain
- Zero Entry Sweeps
- Aeration control/monitoring systems

## **Process Changes**

- Lock out ....no exceptions!
- Air quality testing
- Written housekeeping procedures
- Written bin entry and cleaning procedures
- Discipline policy

# ***Use all of our tools to keep grain in good condition, workers safe, and \$\$\$ in our pockets***

- ✓ Clean
- ✓ Seal/Repair
- ✓ Load Carefully
- ✓ Manage Air
- ✓ Monitor
- ✓ Train
- ✓ Market
- ✓ Plan Ahead
- ✓ Be Safety-Minded
- ✓ Keep Current on New Equipment/Techniques

**Questions?**

[Jcarol@okstate.edu](mailto:Jcarol@okstate.edu)

Oklahoma State University



*Home of World-Class Stored Product Research*

Stillwater, Oklahoma