

Grain Bin Monitoring and Automation

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2015 AGrowStar Meeting
Conway, SC
February 2, 2015



ADVANTAGES OF MONITORING AND AUTOMATION



On-Farm Grain Storage

- Why store grain?
 - Adds flexibility to grain marketing program
 - Relief from harvest delivery pressure
 - Capture post-harvest market prices
- Large on-farm storage bins
 - Cheaper on a \$/bu basis
 - But risky; it's your bank account



Image: agriculture.com



Current State of Monitoring and Automation

- Implementation in 2009
 - Commercial: 90%
 - On-farm: 5%
- Key selling points
 - Reduce drying costs
 - Reduce risk of poor condition
 - Reduce shrink
 - Prevent spoilage
 - Reduce management labor



Advantages of remote monitoring capabilities

- Know what's going on inside the bin
- Proactive management
- Reduce entry/climbing
- Remote grain checking

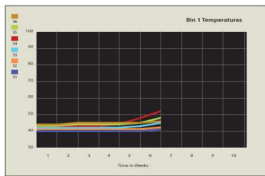


Image: OPI Integris

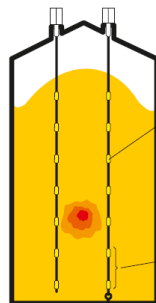
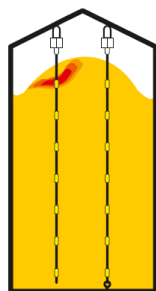


Image: grain-watch.com



Advantages of remote monitoring capabilities

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“Risk Reduction”

“Value Retention”



Advantages of remote monitoring capabilities

- Know what's going on inside the bin
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Why enter a bin?

- Visual inspection
- Probing for quality
- Address caking, clumping, and bridging

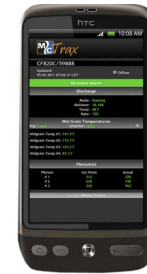
"If we address quality, we can eliminate the need to enter a confined space where the grain is flowing... the only time we're in a bin is when there's a problem."

Bob Marlow, The Andersons Inc.

Advantages of remote monitoring capabilities

- Know what's going on inside the bin
- Proactive management
- Reduce entry/climbing
- Remote grain checking

Email/Text Alarms



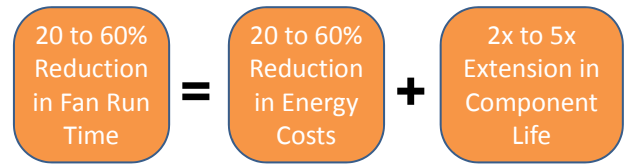
Advantages of automated aeration control

- Moisture optimization and shrink reduction
- Energy savings and extended equipment life



Advantages of automated aeration control

- Moisture optimization and shrink reduction
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Cost of shrinkage and handling

- 1,000 bu Corn @ 15 %wb, 4 \$/bu
 - Total = 56 lb/bu * 1,000 bu = 56,000 lb
 - Moisture = 0.15 * 56,000 lb = 8,400 lb
 - Dry matter = 0.85 * 56,000 lb = 47,600 lb

Value
\$4,000

- Dry down to 13 %wb
 - Handling loss = 47,600 lb * 0.01 = 476 lb
 - Dry matter = 47,600 lb – 476 lb = 47,124 lb
 - Moisture = (0.13 * 47,124 lb) / 0.87 = 7,042 lb
 - Total = 47,124 lb + 7,042 lb = 54,166 lb
 - Bushels remaining = 967 bu

Loss
13.1 ¢/bu

Value
\$3,869

Value of Re-Hydration

- 967 bu Corn @ 13 %wb, 4 \$/bu
 - Total = 54,234 lb
 - Moisture = 7,042 lb
 - Dry matter = 47,124 lb

Value
\$3,869

- Re-hydrate to 15 %wb
 - Dry matter = 47,124 lb
 - Moisture = (0.15 * 47,124 lb) / 0.85 = 8,316 lb
 - Total = 47,124 lb + 8,316 lb = 54,234 lb
 - Bushels sold = 990 bu

Re-Gain
9.1 ¢/bu

Value
\$3,960

COMMERCIALLY AVAILABLE SYSTEMS



What are the commercial options?

- Monitoring
 - Grain temperature
 - Moisture content
 - Insect activity
 - Fan Pressure
 - Inventory
- Logging
 - Historical trends
- Automation
 - Aeration control
 - Weather station
- Communication
 - Alarms
 - Email/text
 - Web interface



IntelliAir



Product	Price*	Price/bu*	Temperature	Moisture	Logging	Inventory	Internet Access	Fan Automation
BinCheck Handheld	\$5k	17c	✓	✓	✓			
BinCheck Deluxe	\$7.5k	25c	✓	✓	✓		✓	
BinManager	\$10k	33c	✓	✓	✓		✓	✓

* Ballpark, based on 30,000 bu bin per Jan 2015 communication with Grain Specialist, Chance Hager



OPI



Product	Price*	Price/bu*	Temperature	Moisture	Logging	Inventory	Internet Access	Fan Automation
StorMax	\$2.6k	9c	✓	+\$900	✓	✓		
Integris Basic	\$9.2k	31c	✓	+\$900	✓	✓	✓	
Integris Pro	\$11.6k	39c	✓	+\$900	✓	✓	✓	✓

* Ballpark, based on 30,000 bu bin per Jan 2015 communication with Grain Specialist, Dan Bruck



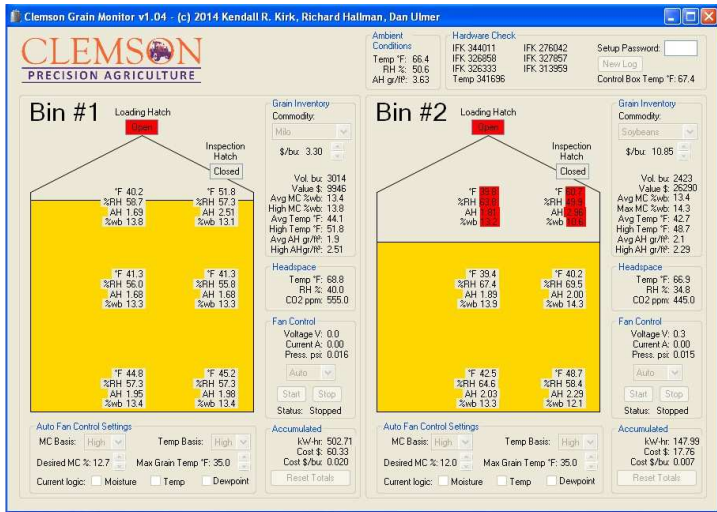
THE CLEMSON BIN AUTOMATION RESEARCH SYSTEM



What is monitored

- Grain temperature
- Moisture content
- Grain inventory
- Fan pressure
- Headspace temp.
- Headspace humidity
- Headspace CO₂
- Fan Pressure
- Fan Amperage
- Fan Voltage
- Ambient temperature
- Ambient humidity
- Inspection hatch
- Loading hatch





Grain Temperature and Moisture Sensing



Equilibrium Moisture Content

- Grain moisture content when exposed to:
 - Particular temperature
 - Particular relative humidity

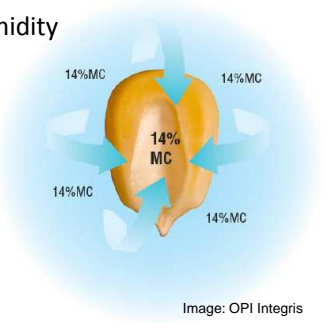


Image: OPI Integris

Equilibrium Moisture Content

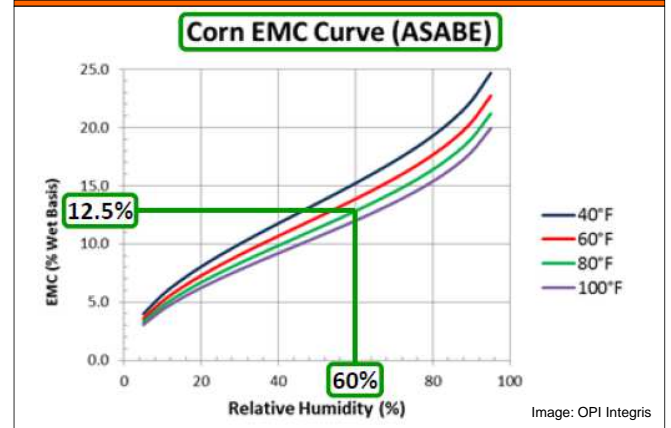
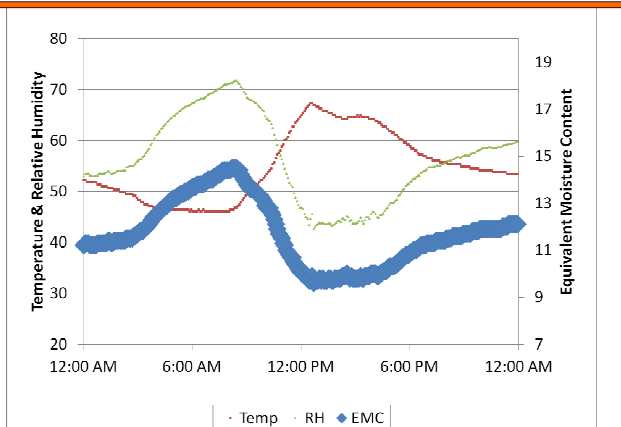


Image: OPI Integris

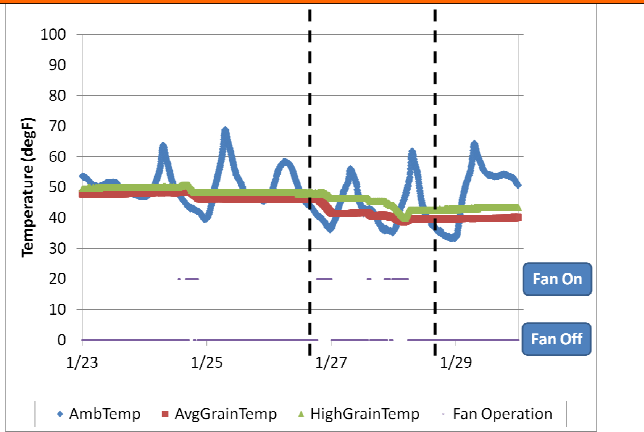
Equilibrium Moisture Content



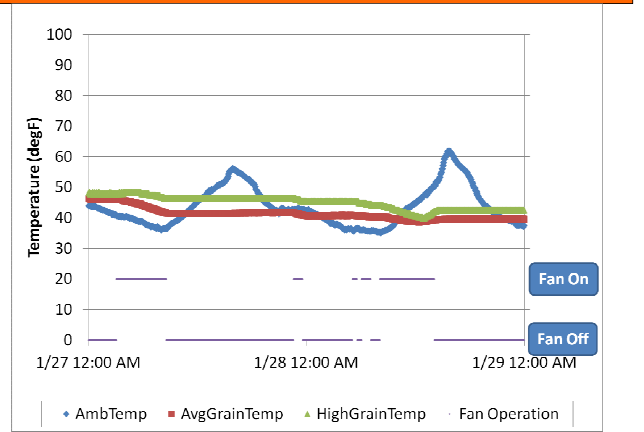
Automated Fan Control Logic

- Cooling
 - If Grain Temperature > Setpoint
 - If Ambient Temperature < Grain Temperature
- Drying
 - If Grain Moisture > Setpoint
 - If Ambient Humidity < Grain Porespace Humidity
- Condensation Prevention
 - If Headspace Temp < Headspace Dewpoint Temp

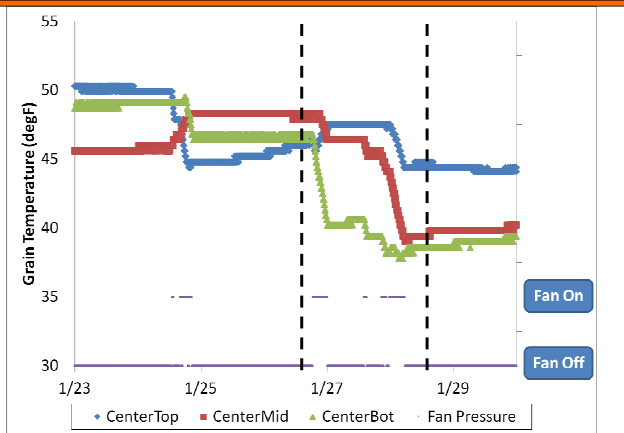
Temperature - One Week



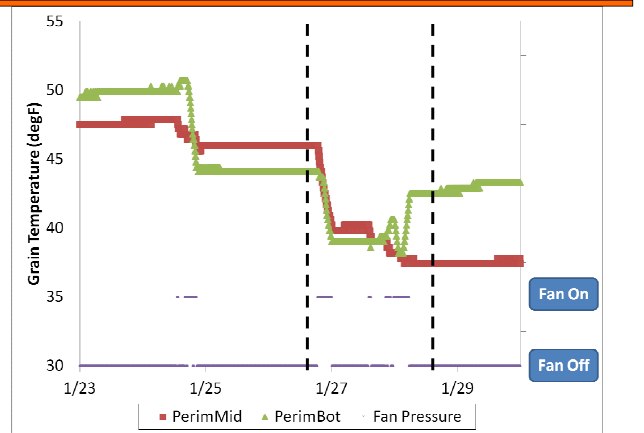
Temperature - Two Days



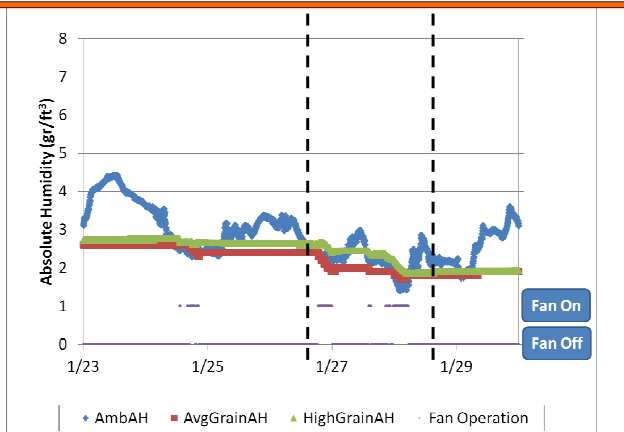
Temperature - Center Cable



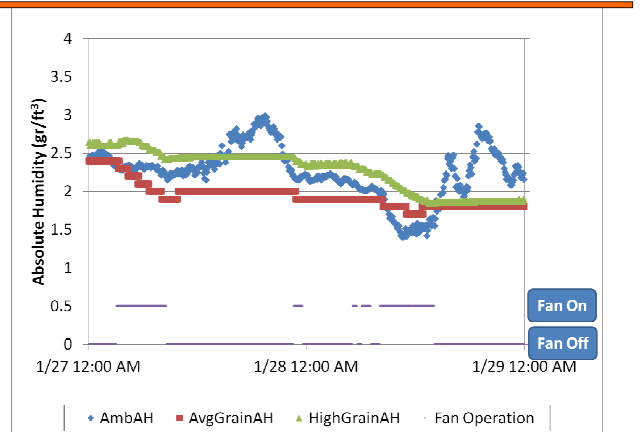
Temperature - Perimeter Cable



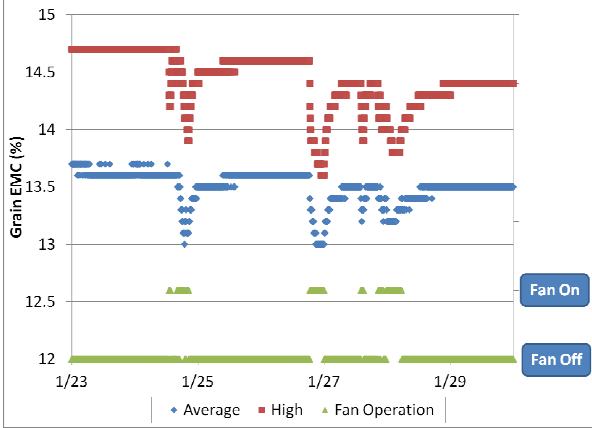
Absolute Humidity - One Week



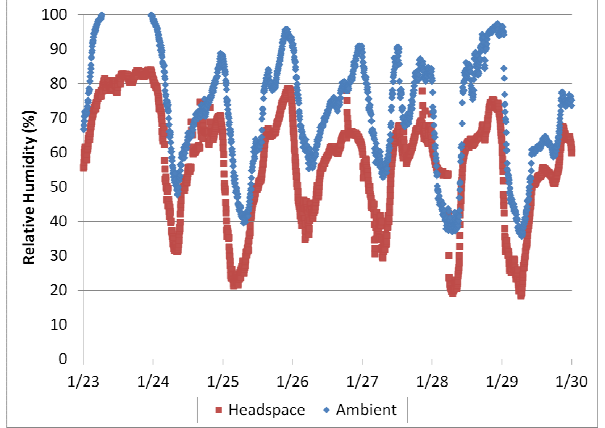
Absolute Humidity - Two Days



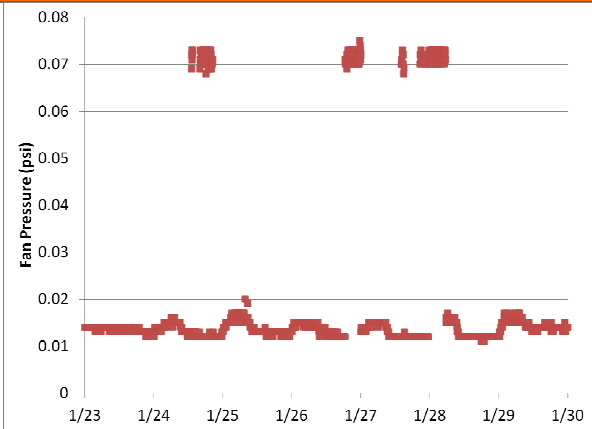
Grain Moisture Content – One Week



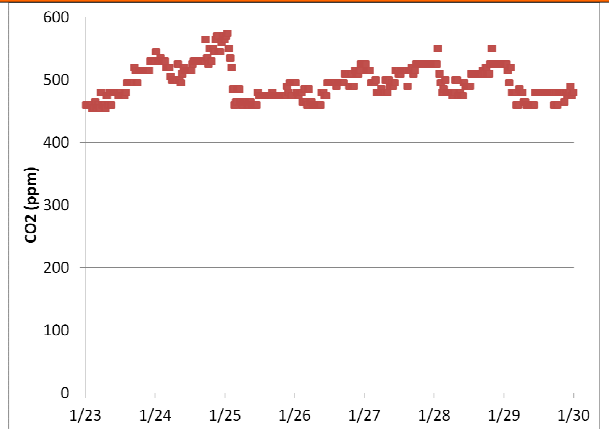
Relative Humidity – One Week



Fan Pressure – One Week



Headspace CO₂ – One Week



Plans for the Clemson Bin Automation Research System

- Develop storage recommendations for milo
- Evaluate and demonstrate return on investment for bin automation
- Determine alarm points for CO₂
- Evaluate fan control logic
- Demonstrate advantages of monitoring and automation

Questions?

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GRAIN STORAGE: USEFUL REFERENCES



Allowable Storage Time – Cereal Grains

Moisture Content (%)	--- Grain Temperature (°F) ---					
	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



* >300 days
Source: NDSU Extension



Allowable Storage Time – Soybeans

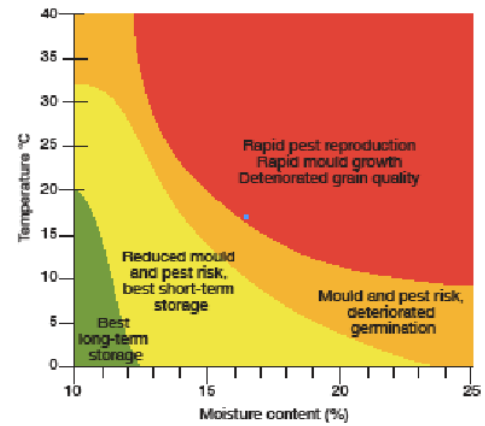
Moisture Content (%)	--- Grain Temperature (°F) ---					
	30°	40°	50°	60°	70°	80°
	Approximate Allowable Storage Time (Days)					
11	*	*	*	*	200	140
12	*	*	*	240	125	70
13	*	*	230	120	70	40
14	*	280	130	75	45	20
15	*	200	90	50	30	15
16	*	140	70	35	20	10
17	*	90	50	25	14	7
19	190	60	30	15	8	3
21	130	40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



* >300 days
Source: NDSU Extension



Effects of Temperature and Moisture on Stored Grain



Source: storedgrain.com.au



Safe Moisture Storage for Grain and Seed

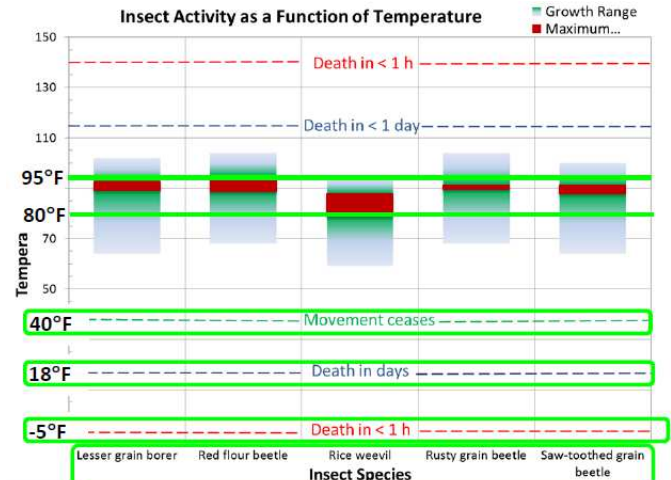
Seed	Grain and Seed Long-term Storage			Storage Temperature Should be Below °F
	2 months	6 months	Maximum Grain Moisture (%)	
Barley	—	13.4	11.9	77
Buckwheat	—	13.9	12.4	77
Corn, grain	14.8	14.0	12.4	77
Corn, grain	15.2	14.2	12.6	60
Corn, grain	17.7	15.5	13.9	40
Corn, ear ²	—	20.0	—	50
Oats	—	12.8	11.4	77
Millet	—	10.0	9.0	70
Peanuts, unshelled	11.2	9.8	8.4	70
Peanuts, unshelled	12.0	10.3	8.9	50
Peanuts, shelled	8.8	7.7	6.7	70
Peanuts, shelled	9.1	8.1	7.2	50
Rye	—	13.9	12.3	77
Soybeans	15.8	12.0	9.7	77
Soybeans	16.1	12.4	10.1	60
Soybeans	16.5	12.9	10.4	40
Sunflowers, oil	—	9.8	8.6	77
Sunflowers, non-oil	—	10.0	9.0	77
Sorghum	14.7	13.5	12.4	90
Sorghum	15.2	14.0	13.0	60
Wheat, soft red winter	15.6	13.6	12.1	77
Wheat, soft red winter	15.8	14.0	12.4	70
Wheat, soft red winter	16.0	14.4	13.1	40
Alfalfa	—	—	7.8	73
KY bluegrass	—	—	11.3	73
Clover, red	—	—	9.1	73
Clover, white	—	—	8.7	73
Crown vetch	—	—	9.4	73
Tall fescue	—	—	12.1	73
Orchardgrass	—	—	11.0	73
Ryegrass	—	—	12.8	73
Timothy	—	—	12.5	73

¹ Safe storage depends on many factors such as temperature, humidity, kind and variety of seed, quality, damage, microorganisms, length and kind of storage. Stored grains and seed should be inspected frequently for changes in temperature and moisture as well as pest infestations.
² Ventilated cribs 6-8" wide.

Source: Va. Extension Agronomy Handbook



Insect Activity as a Function of Temperature



Source: OPI Integris



Insects of Stored Grain – Resistance to Low Temperatures

Insect	Days Exposure Required to Kill All Stages at ¹						
	0°-5°F	5°-10°F	10°-15°F	15°-20°F	20°-25°F	25°-30°F	30°-35°F
Rice weevil	1	1	1	3	6	8	16
Granary weevil	1	3	—	14	33	46	73
Saw-toothed grain beetle	1	1	3	3	7	23	26
Confused flour beetle	1	1	1	1	5	12	17
Red flour beetle	1	1	1	1	5	8	17
Indian-meal moth	1	3	5	8	28	90	—
Mediterranean flour moth	1	3	4	7	24	116	—