Maintaining Grain Quality in Storage

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Post-Harvest Update and Recertification Workshop

December 16, 2013

Beck Ag. Center, West Lafayette, Indiana

Grain Post-Harvest Team

Presentation Outline

- 2013 Corn and Soybean Quality Brief
- Emerging Issues
- Basics of Stored Grain Management
- Application of S.L.A.M.

2013 Corn & Soybean Quality

- Overall it was a good year for both crops
- Crop harvested timely came out of field with good storage characteristics
- Crops harvested late in November where hit by frost and rewetting which created field variability in moisture and difficult drying conditions

Emerging Issues

- Increased cases of bin entrapment/engulfment
- Increased on-farm storage capacity
- Managing grain quality in a bad year
- High levels of CO_2 emitted from wet corn in 2013
- Effective and safe monitoring of stored grain in silos and grain piles

Entrapments on the rise

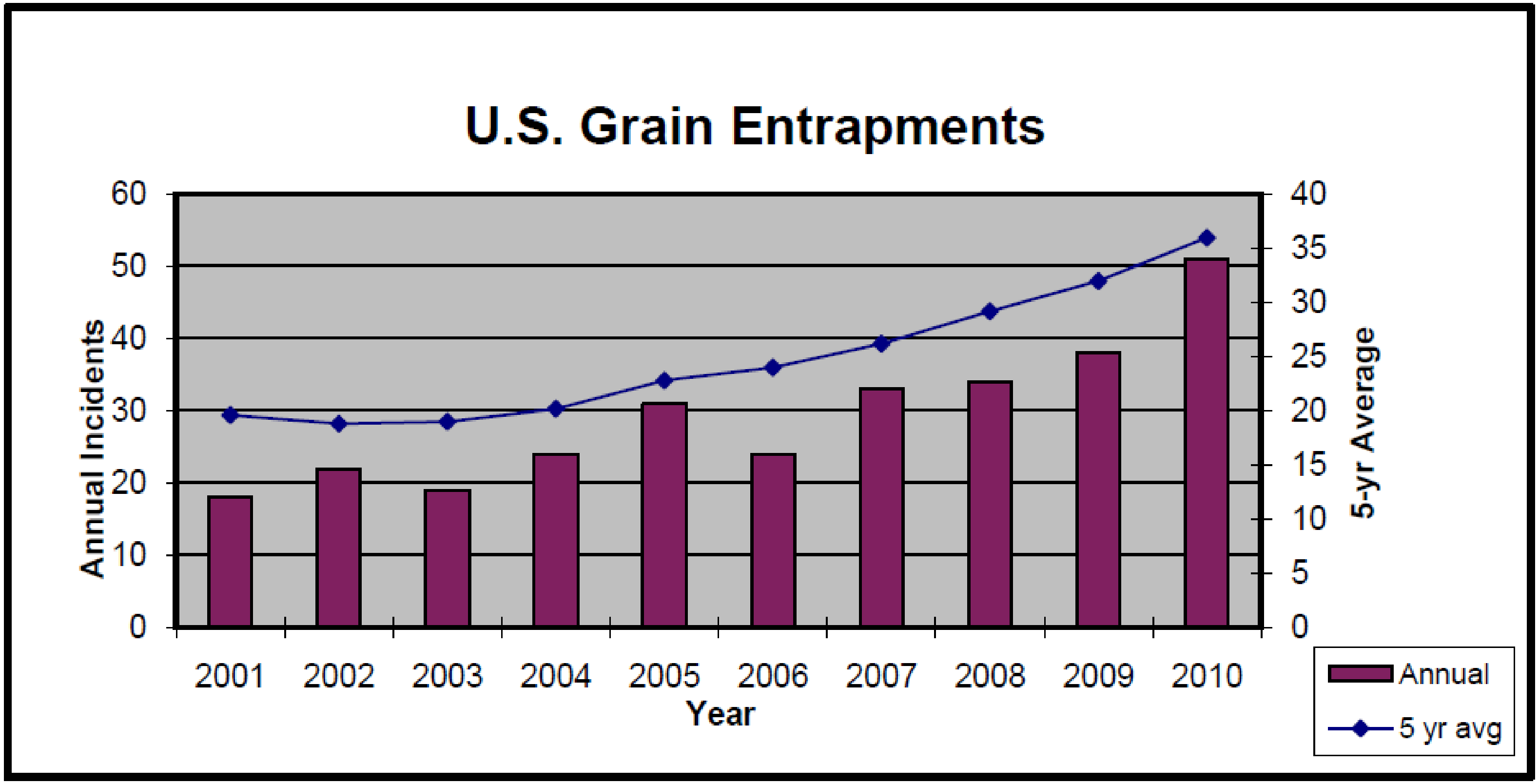
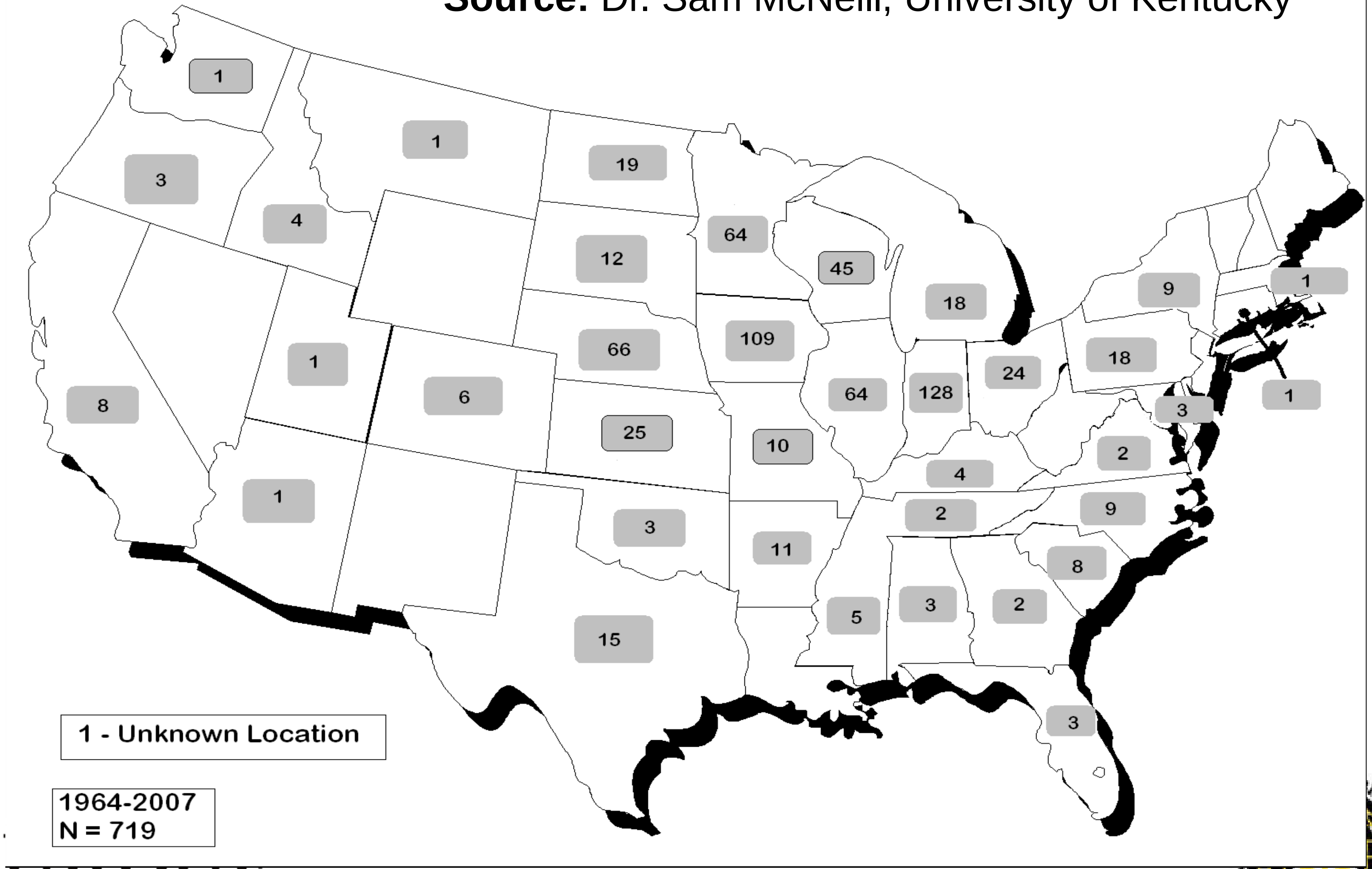


Figure 1: Number of annual grain entrapments[3] recorded in the National Grain Entrapment Database and the 5-year average between 2001 and 2010.

Source: Riedel, S and W. Field. 2010. 2010 summary of grain entrapments in the United States. February 9, 2011.

Entrapments by Geographic Location

Source: Dr. Sam McNeill, University of Kentucky



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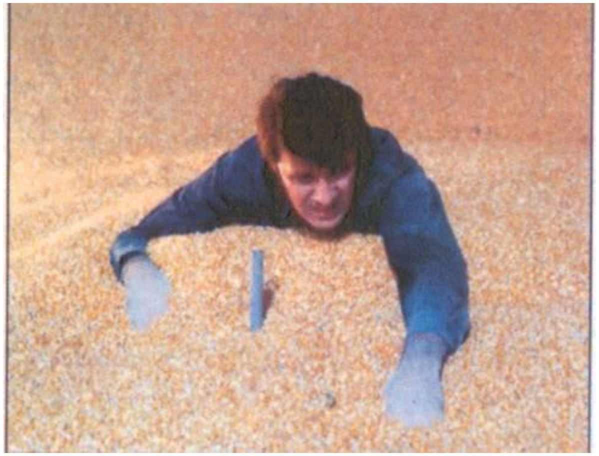
Documented Contributing Factors

- No. 1 identified cause of entrapment was out-of-condition grain
- High capacity grain handling systems
- Working alone
- Relaxed compliance with workplace safety regulations
- Lack of knowledge concerning the risk

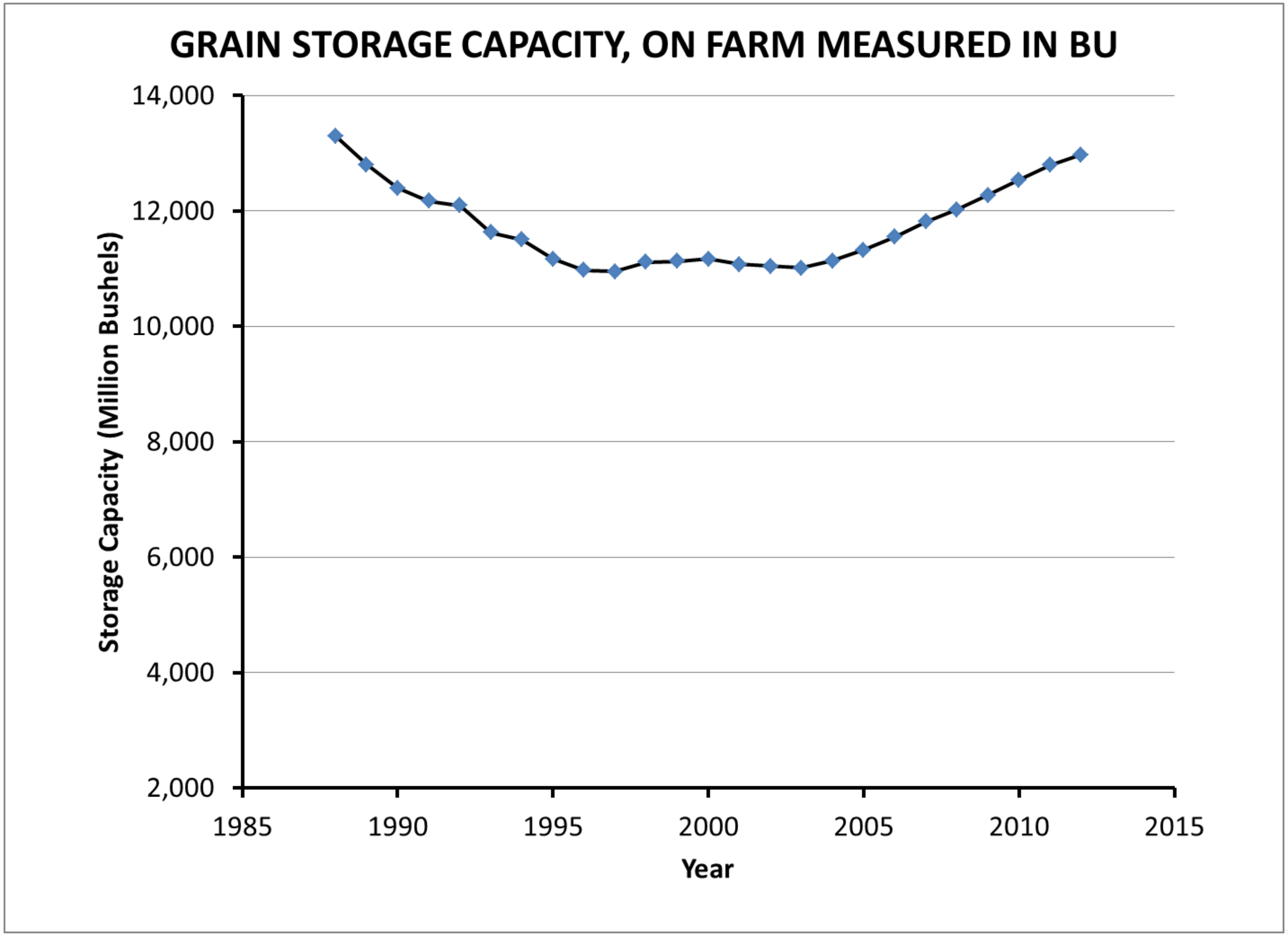
The Major cause of grain entrapments

- There continues to be a direct relationship between ‘out-of-condition’ or spoiled grain, and greater probability of entrapment (Riedel and Field, 2010)



Source: Riedel, S and W. Field. 2010. 2010 summary of grain entrapments in the United States. February 9, 2011.

U.S. On-Farm Storage Capacity



Data Source: USDA-NASS, 2013

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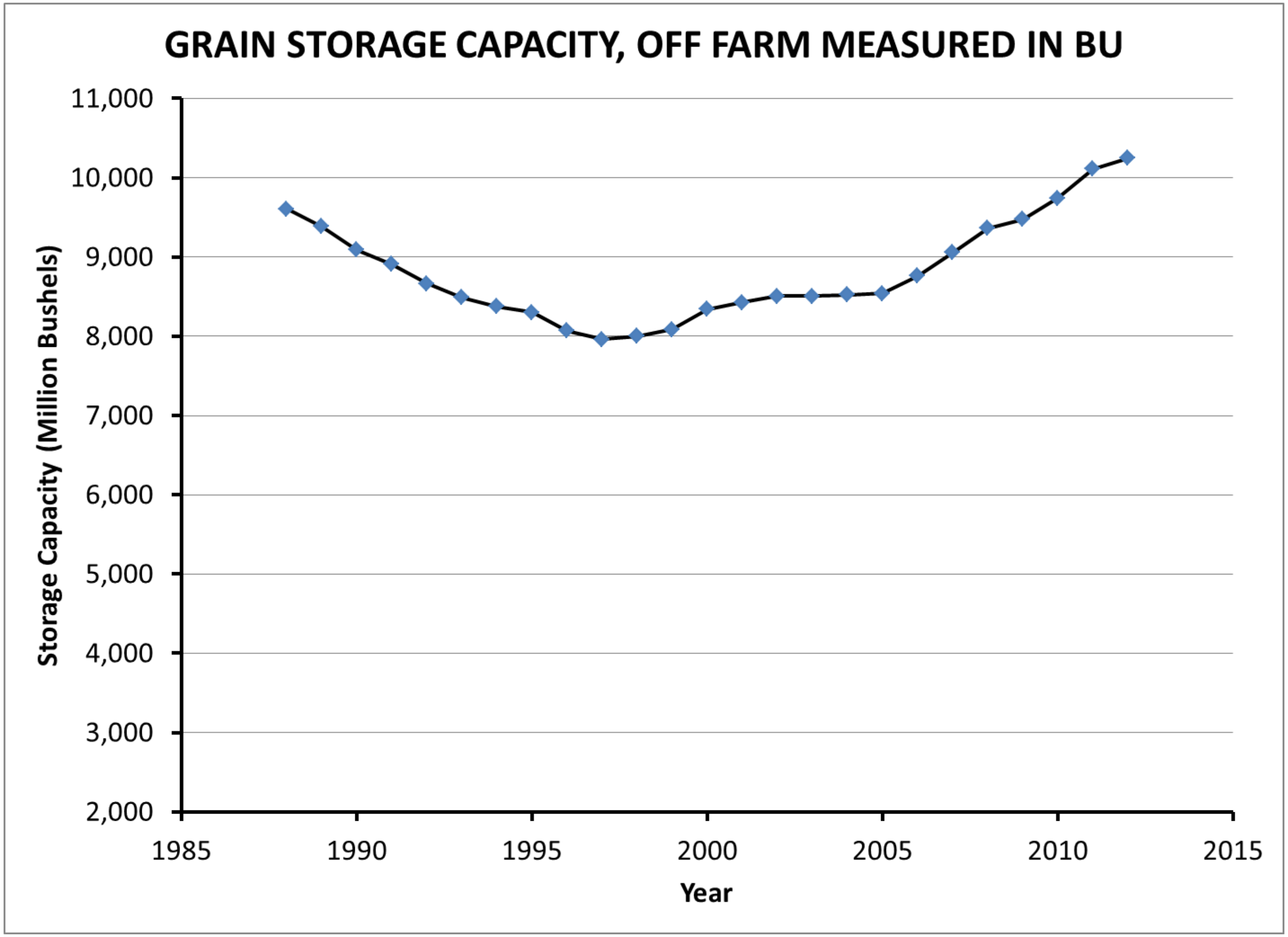
U.S. Off-Farm Storage Capacity



Data Source: USDA-NASS, 2013

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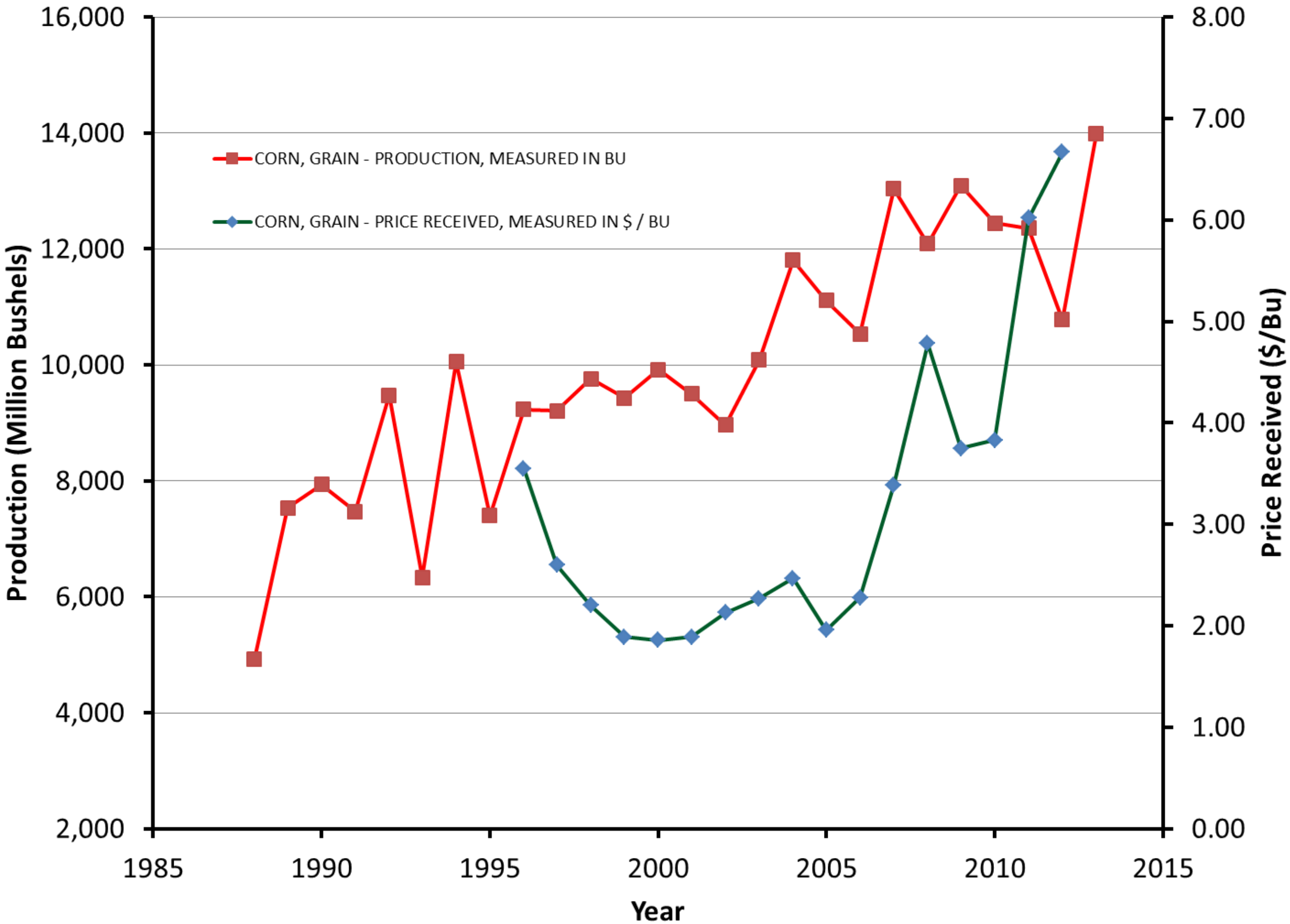
U.S. Corn Production and Price



Data Source: USDA-NASS, 2013

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How do you manage quality in a bad crop year?

- 2009 was a bad crop year with several challenges:
  - Wet conditions made harvest a challenge.
  - Field damaged corn from ear rot, etc. made post-harvest handling a challenge.
  - Higher levels of mycotoxin and mold in corn from the field made storage a challenge.
  - Higher levels of fines and broken corn

2013 was a good crop year !!!

CO_2 Emitted from Wet Corn

High-Moisture Levels in **Some New-Crop Corn** Deliveries May Warrant Atmospheric Testing to Protect Employees – NGFA, 2013

- Isolated incidents where the post-harvest respiration of some new-crop harvested corn appears to be occurring rapidly after unloading; thus, leading to **elevated levels of carbon dioxide (CO_2) and depleted oxygen levels** -- -- particularly in low-lying storage areas - both at farms and commercial facilities.

Challenges in Large Grain Stock Management

- On-farm bin sizes installed are larger in capacity.
- Most farm bins have no monitoring tool.
- When a monitoring tool is available, typically a temperature cable, it is not enough for effective management.
- Lack of effective management of large grain stocks.

Basic Concepts of Stored Grain Management

- Grain is a biologically active material and therefore it will deteriorate in storage under favorable conditions

- Stored grain quality cannot be improved but maintained.

- Therefore, knowing the history and initial grain quality is an important first step in managing grain in storage

Grain Quality after Storage = F(QualityT_s, Mgt, ?)

How can we accurately predict this?

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Your Investment in Storage

Maintaining Quality is Job # 1 in Stored Grain Management

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The Stored Grain Ecosystem

Grain

Other plant materials

Temperature

Insects, mites, rodents, birds

Grain moisture & RH

Contaminants: frass, faeces, etc.

Gases: CO_2 & O_2

Mold & Mycotoxins

Solar radiation, precipitation, etc.

Phy., chem. & biol. controls

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Factors that Affect Grain Spoilage in Storage

Grain deterioration of stored grain depends on

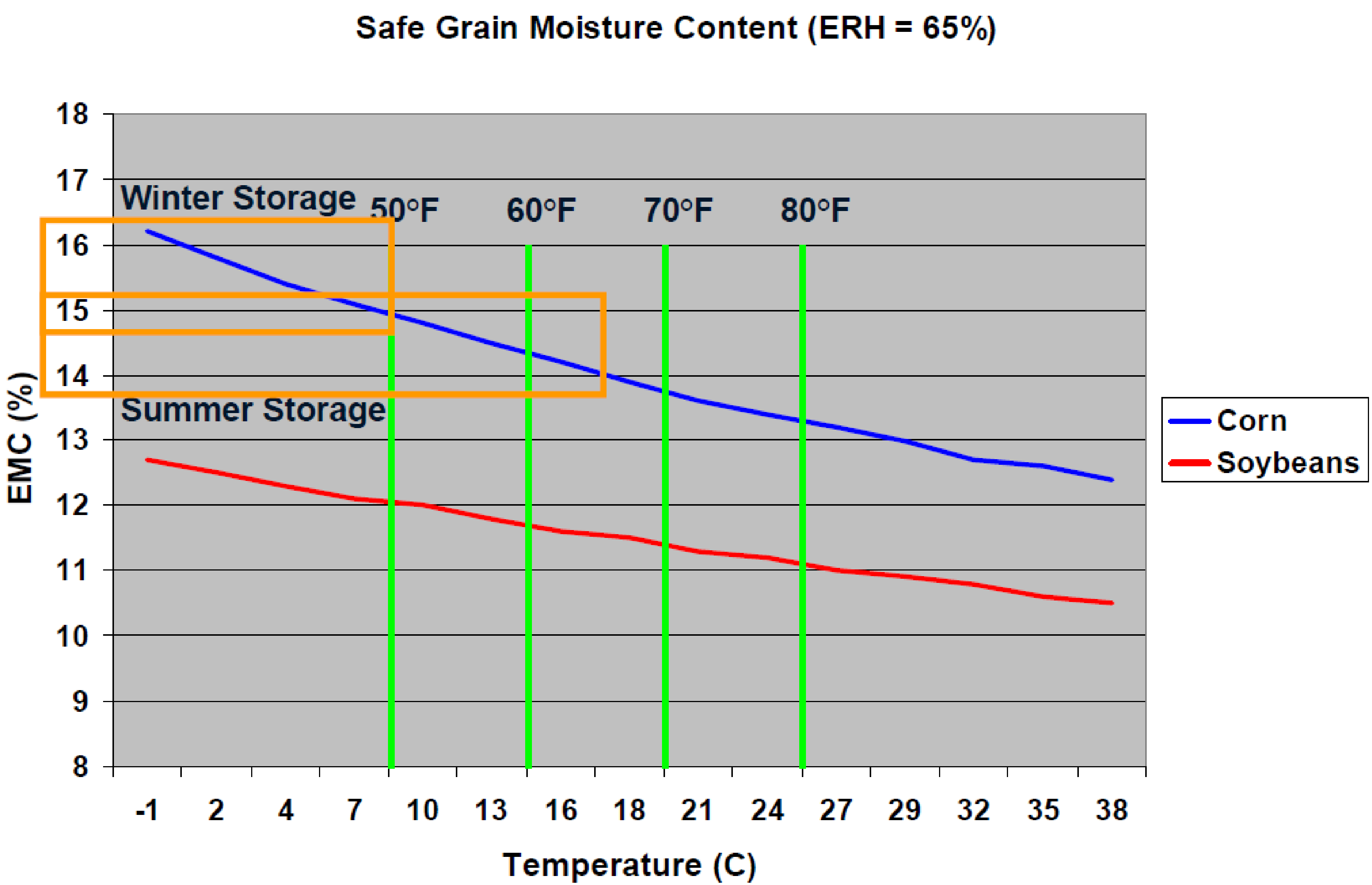
- Moisture, broken kernel, fines and foreign material
- Initial storage mold infestation
- Initial insect pest infestation and insect pest type
- Grain quality (presences of fines/intact kernels)
- Sanitation
- Stored grain environment
  - Temperature and Relative Humidity (RH)
  - CO_2 and O_2
- Stored Grain Management

Storage Life of Grain

Maximum storage time (months) for corn and soybean*							
Corn temperature ° F	Moisture Content Corn *(top %)*, Soybean *(bottom%)*						
	13%, 11%	14%, 12%	15%, 13%	16%, 14%	17%, 15%	18%, 16%	24% N/A
40	150	61	29.0	15.0	9.4	6.1	1.3
50	84	34	16.0	8.9	5.3	3.4	0.5
60	47	19	9.2	5.0	3.0	1.9	0.3
70	26	11	5.2	2.8	1.7	1.1	0.2
80	15	6	2.9	1.6	0.9	0.9	0.06

*Based on 0.5% maximum dry matter loss—calculated on the basis of USDA research at Iowa State University. Corresponds to one grade number loss; 2-3% points in damaged seeds. Soybean approximated at 2% lower moisture than corn.

Source: http://www.extension.iastate.edu/CropNews/2009/1015hurburghelmore.htm



Source: Dr. Dirk Maier, Kansas State University

S.L.A.M.

Sanitation

Loading

Aeration

Monitoring

The concept of SLAM for stored grain systems was developed in the 1990s by Purdue University Extension Engineer and Specialists: **Dr. Dirk Maier** (Agricultural Engineer), **Dr. Linda Mason** (Stored-Product Entomologist) and **Dr. Charles Woloshuk** (Stored-Product Pathologist).

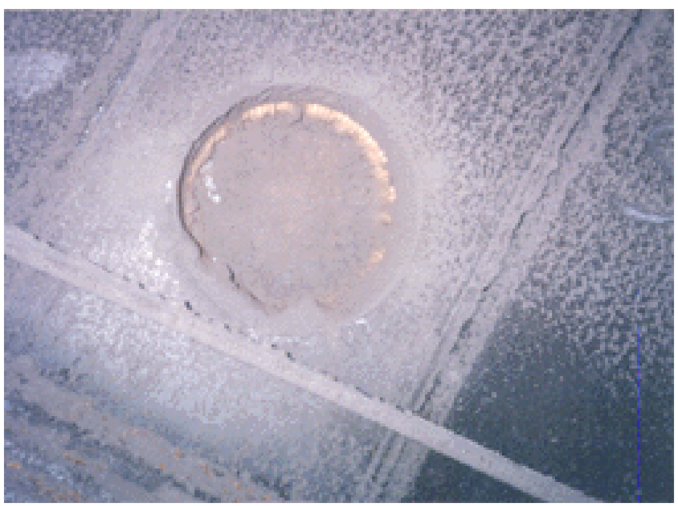
Acknowledgements:
Thanks to Dr. Linda Mason, Purdue Entomology Department and Dr. Dirk Maier, Department Head at Kansas State University Grain Science Program and Mr. Dave Crompton, Integris USA, LLC. for providing the contents of this presentation.

Sanitation

Think Insect Clean!

Eliminate Insect Harborage – under floor sanitation, cracks and crevices

Clean Roof Vents to Prevent Aeration Problems



Pest Prevention

Empty Bin Treatment

Loading

Eliminate the potential for loading by:

- Cleaning grain to remove fines and foreign material
- Drying grain gently by using appropriate drying techniques to prevent stress cracks
- Handling gently using appropriate grain conveying devices

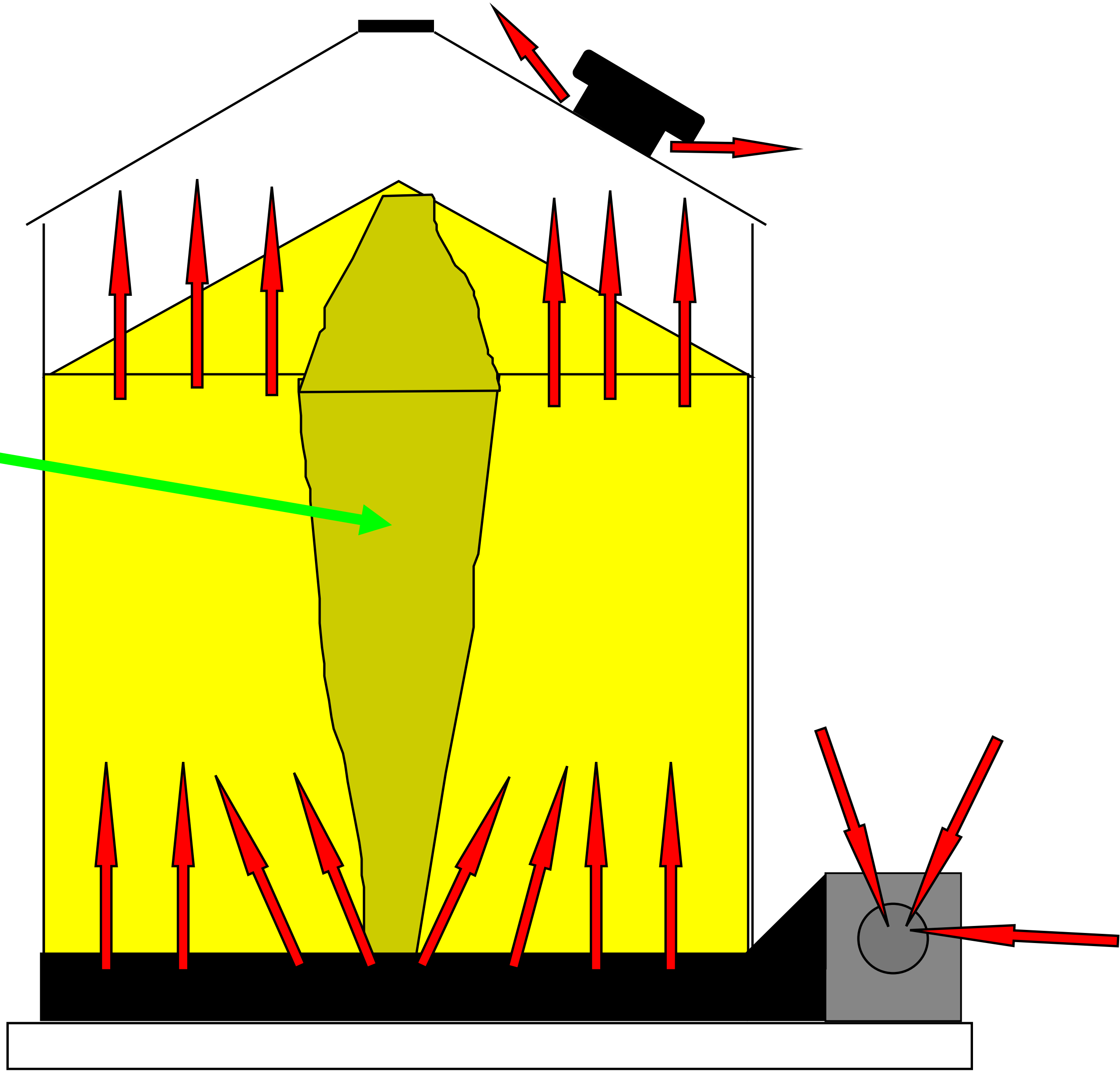
Pre-Cleaning

Cushion Boxes and Flow Retarders

Bin Entrapment Rescue in Spring 2005

What do you think was the cause of this event?

- Core of fines
  - Foreign Material (FM)
  - Broken grain & fines
  - Weed seeds

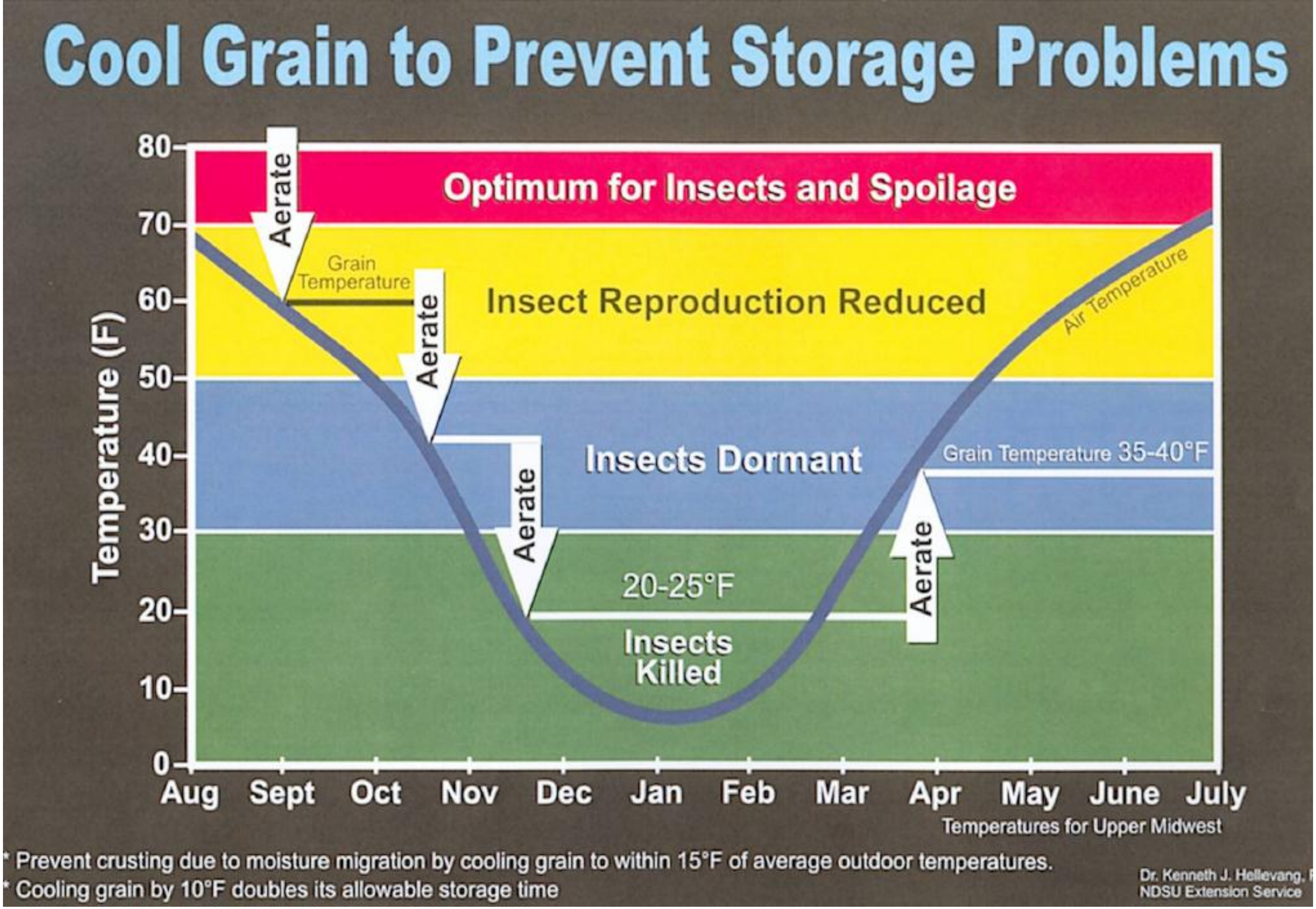


Aerate – to slow down bio-activity

Temperature Influence on Insects

Fields, 1992

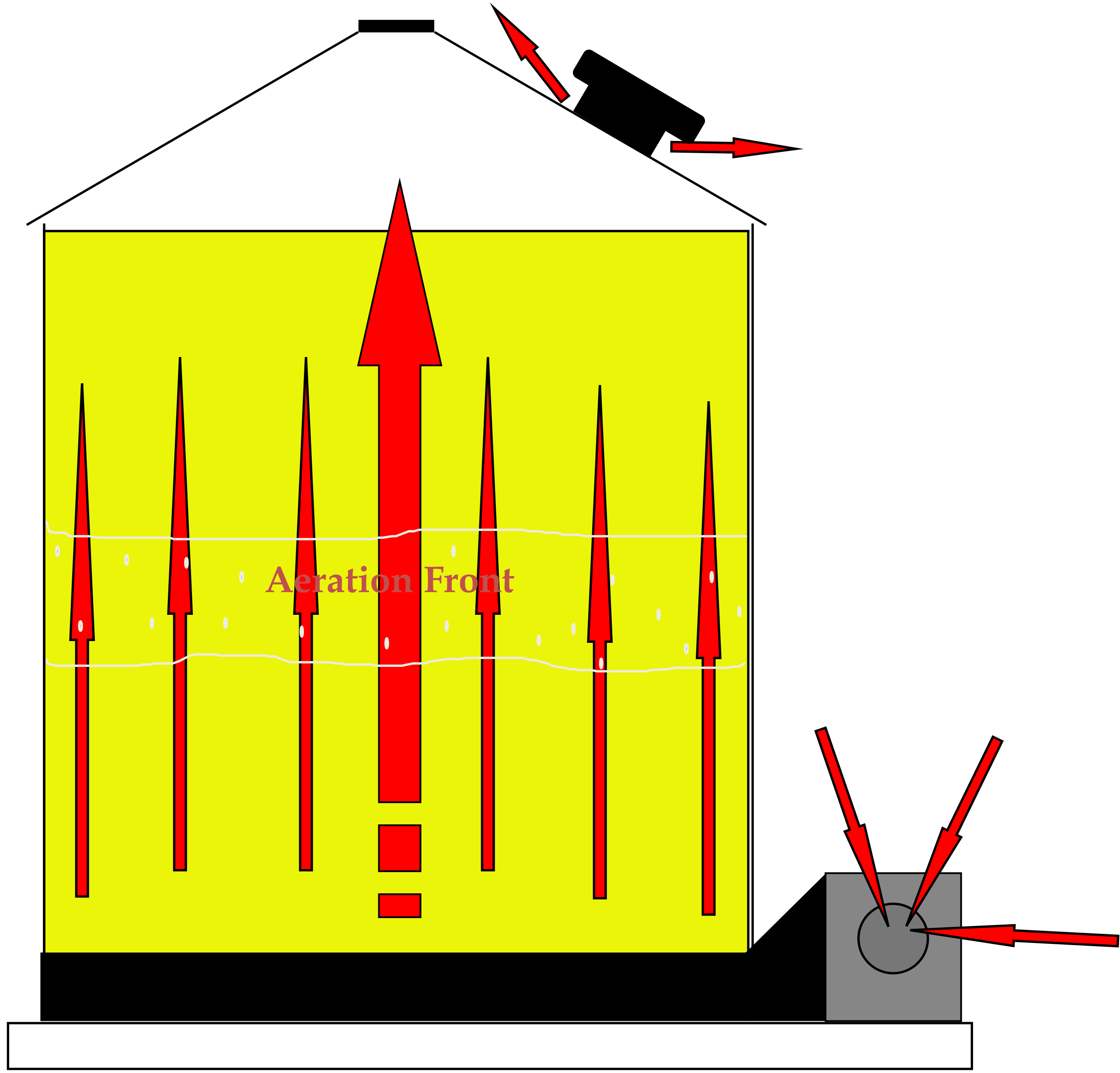
Temperature (^oF)	Effect
122+	Death in minutes
95+	Development stops
77-90	Optimum
66-77	Sub-optimum
41-60	Death in days
0	Death in minutes



Source: Dr. Kenneth Hellevang, North Dakota State University

Move ***Aeration Front*** through grain mass as quickly as possible!

Depends on Air EMC and Airflow

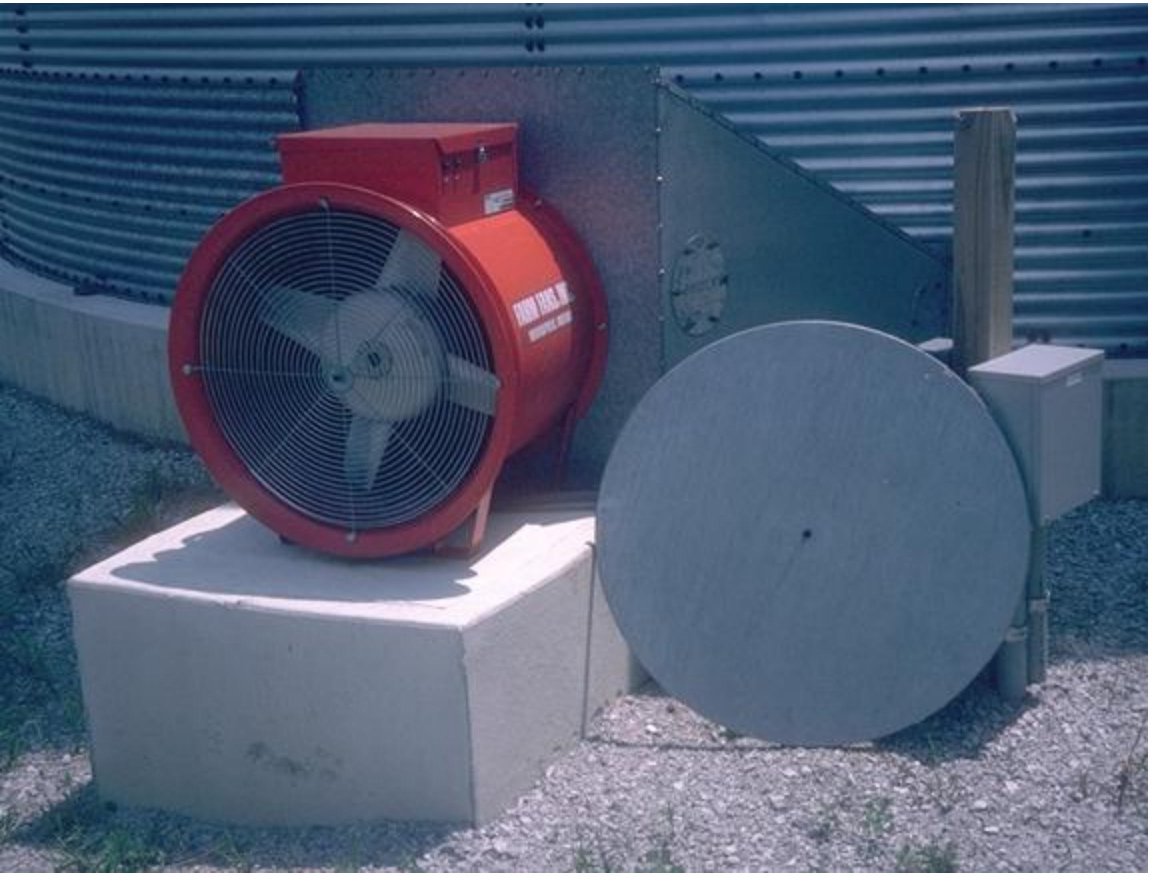


Aeration Phases

- **Phase 1: Fall Cool Down**
  - Lower grain temperatures stepwise
    - October – 40-45°F
    - November – 35-40°F
    - December – 28-35°F
- **Phase 2: Winter Maintenance**
  - Maintain low temperatures with intermittent aeration: January, February- 28-35°F
- **Phase 3: Spring Holding**
  - Keep grain cold from winter aeration
    - Seal fans
    - Ventilate only headspace intermittently

No Summer Aeration to warm-up grain !

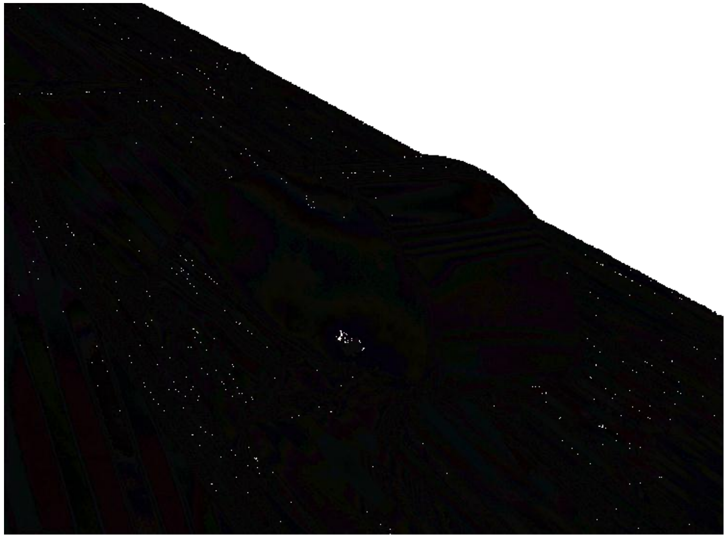
Source: Dr. Dirk Maier, Kansas State University

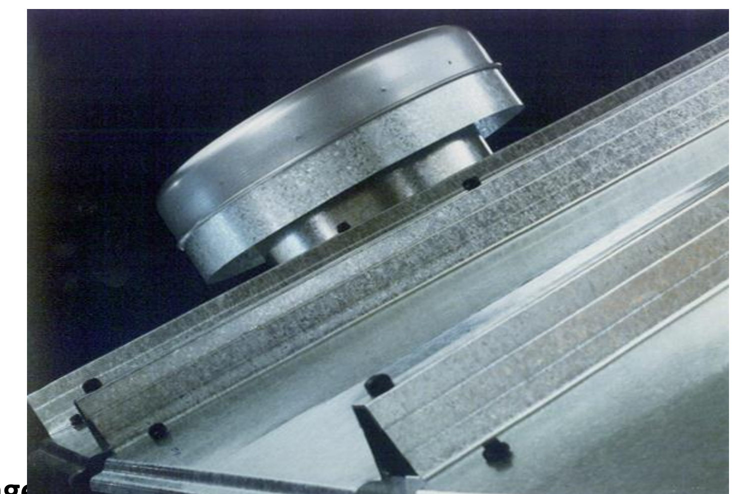


Open Fan

Sealed Fan

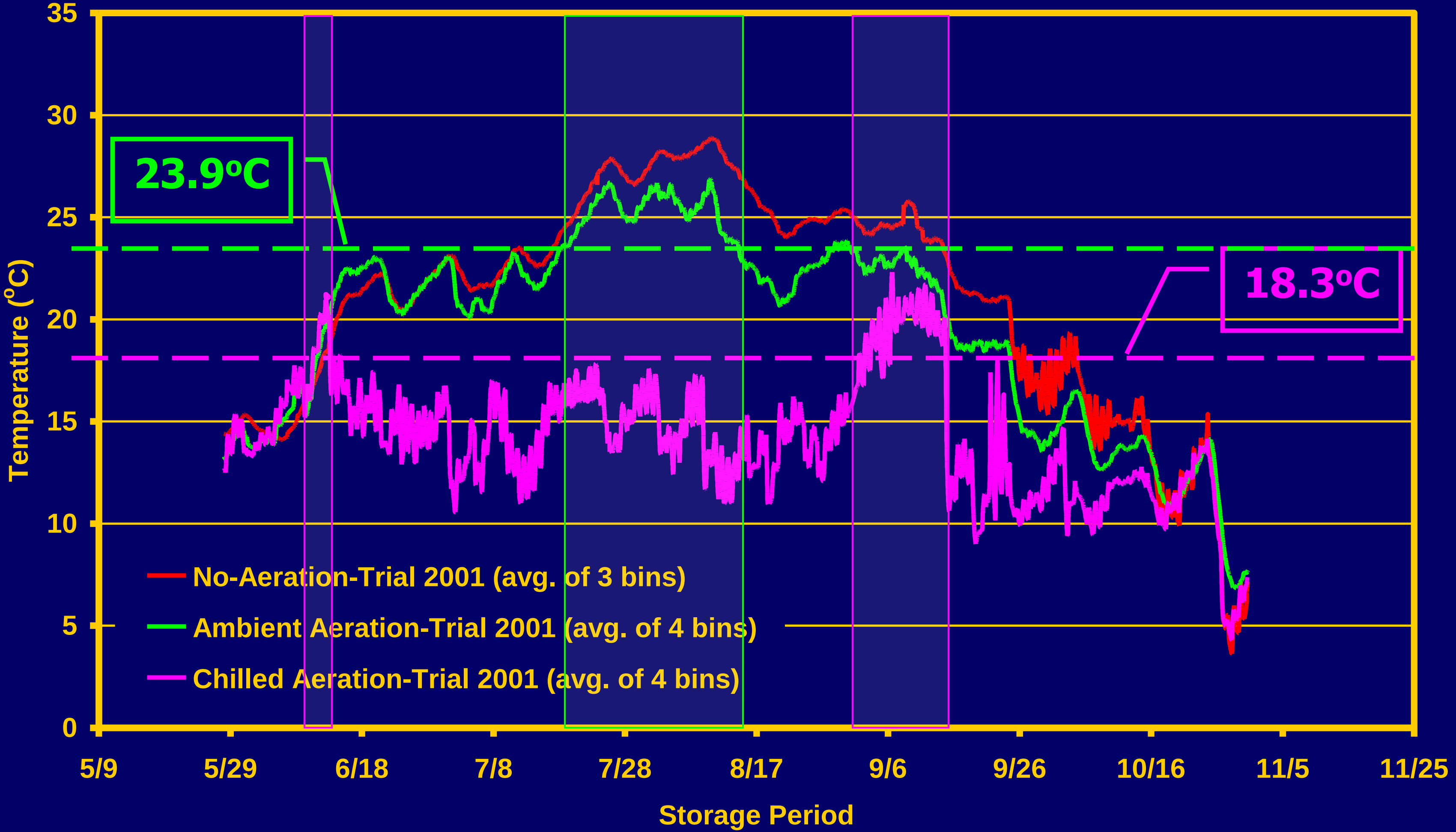
Headspace Ventilation



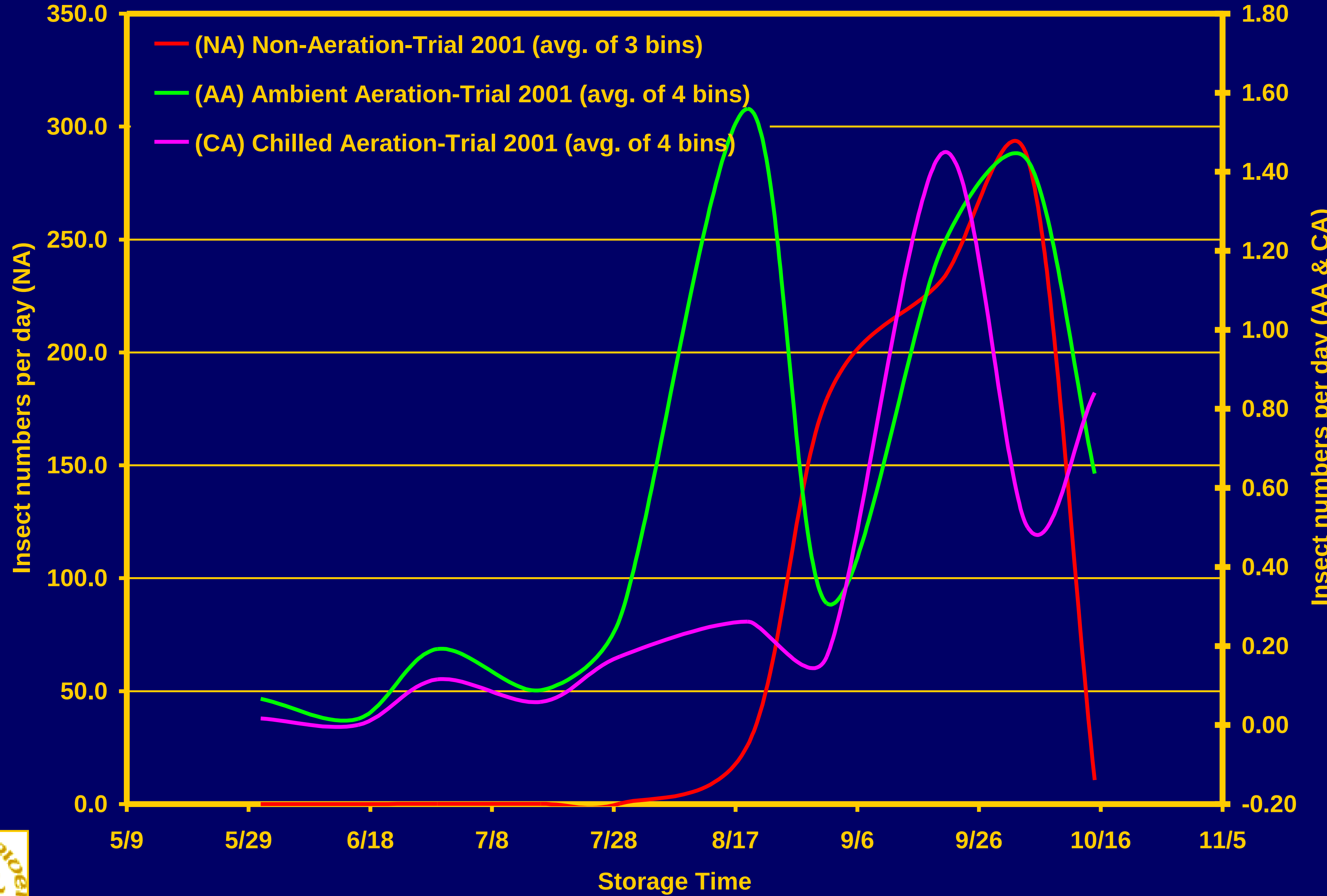


Storage

Grain bulk temperature - 2001

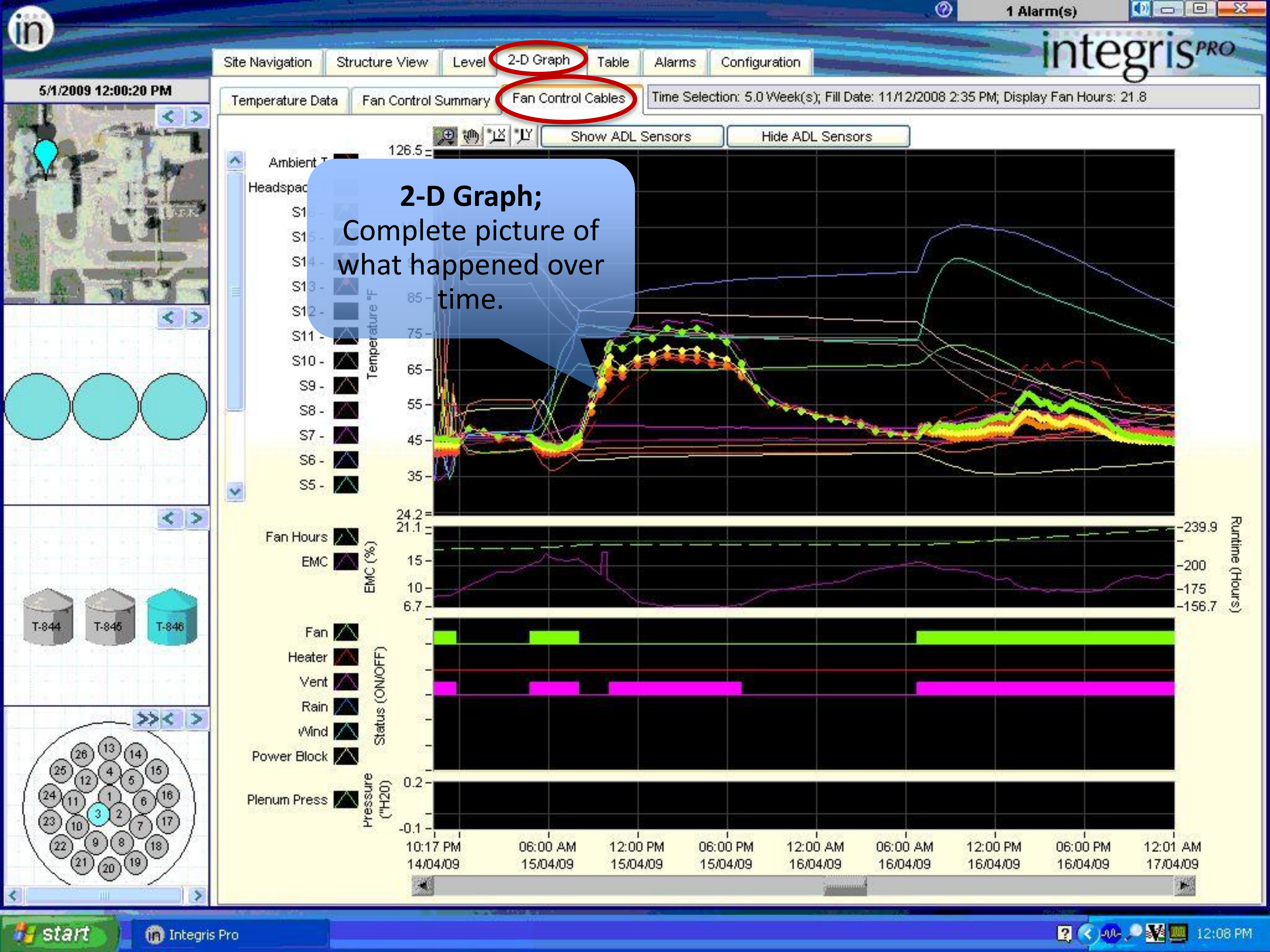


Probe Trap Data - 2001



Monitoring:

You can't manage what you don't know is there

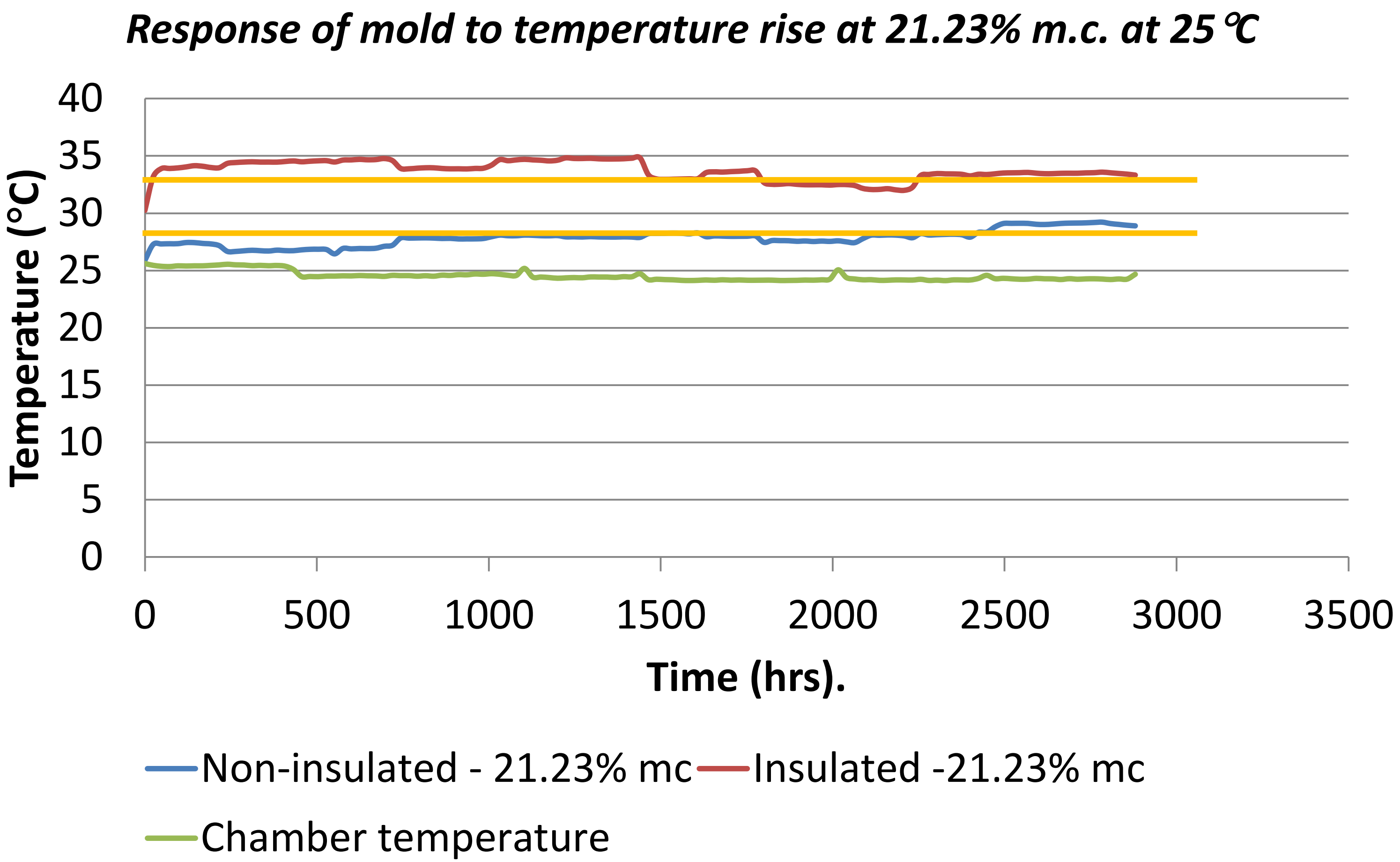


2-D Graph;
Complete picture of what happened over time.
1 Alarm(s)
integris PRO
Site Navigation
Structure View
Level
2-D Graph
Table
Alarms
Configuration
5/1/2009 12:00:20 PM
Temperature Data
Fan Control Summary
Fan Control Cables
Time Selection: 5.0 Week(s); Fill Date: 11/12/2008 2:35 PM; Display Fan Hours: 21.8
Show ADL Sensors
Hide ADL Sensors
Temperature °F
EMC (%)
Runtime (Hours)
Status (ON/OFF)
Pressure ("H20)
Fan Hours
EMC
Fan
Heater
Vent
Rain
Wind
Power Block
Plenum Press
T-844
T-845
T-846
10:17 PM 14/04/09
06:00 AM 15/04/09
12:00 PM 15/04/09
06:00 PM 15/04/09
12:00 AM 16/04/09
06:00 AM 16/04/09
12:00 PM 16/04/09
06:00 PM 16/04/09
12:01 AM 17/04/09
start
Integris Pro
12:08 PM

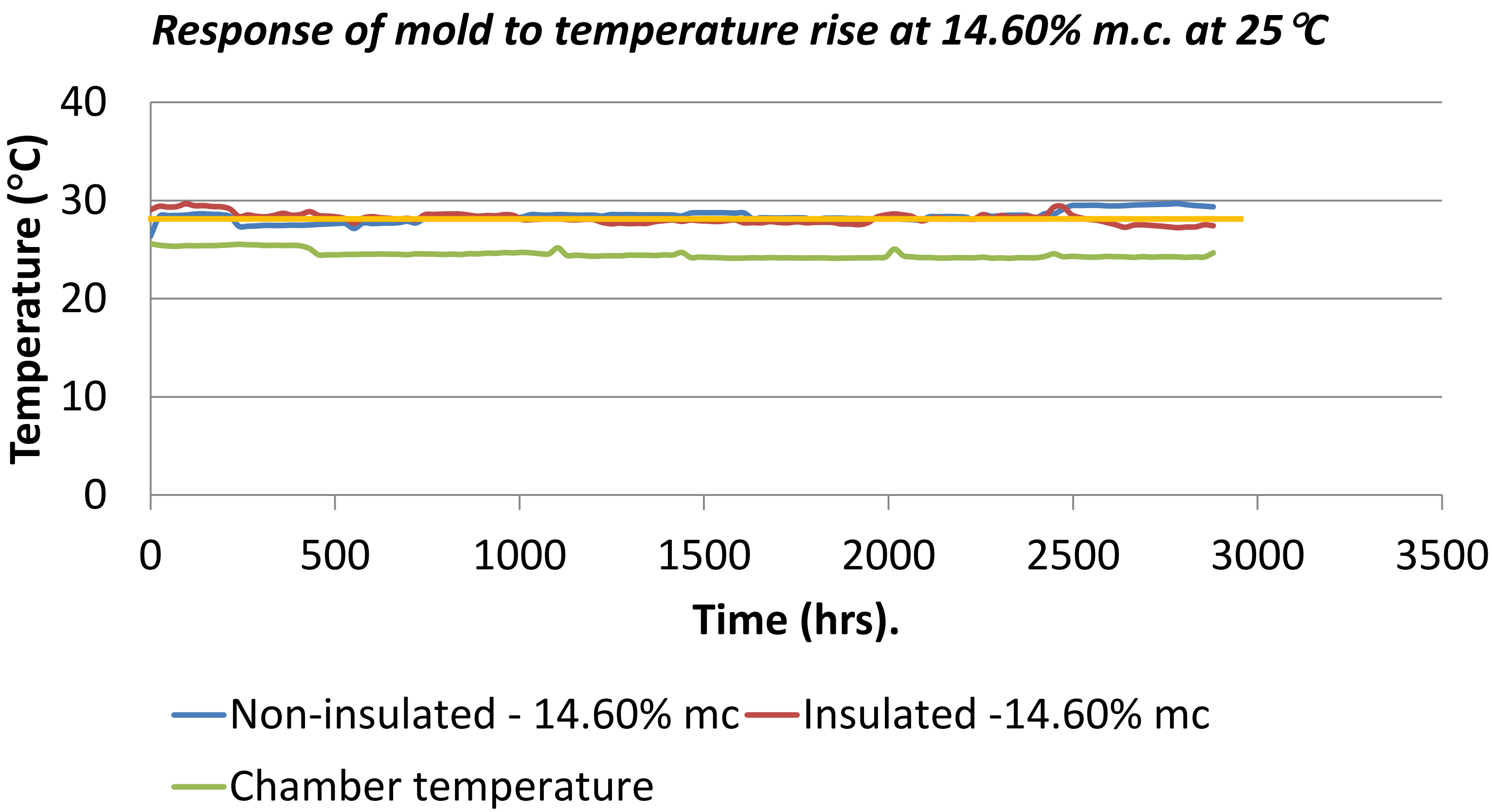
Monitor temperature with temperature cables

It takes a while to detect deterioration and hot spots using temperature cables alone

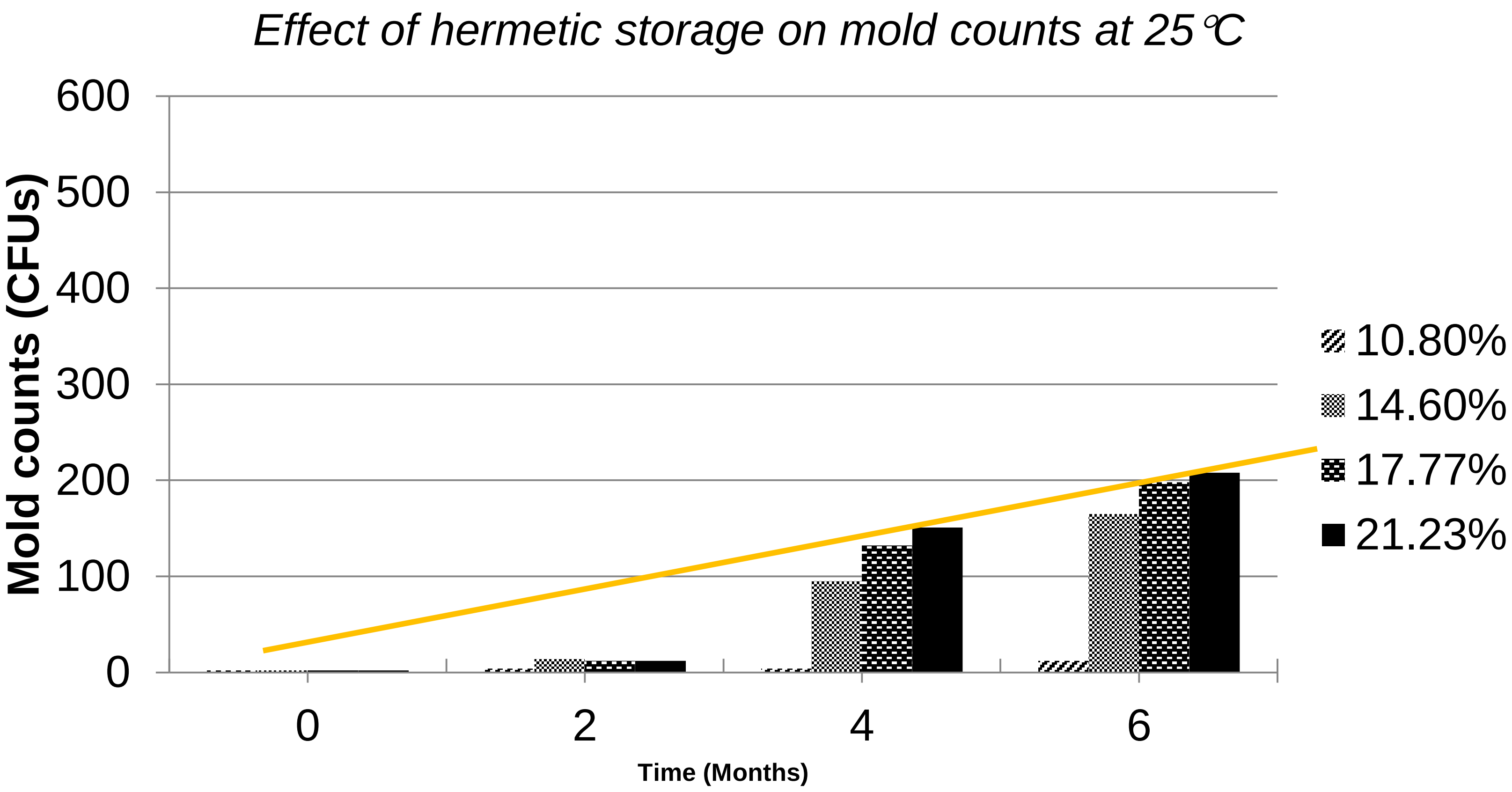
Temperature – 21.23% mc



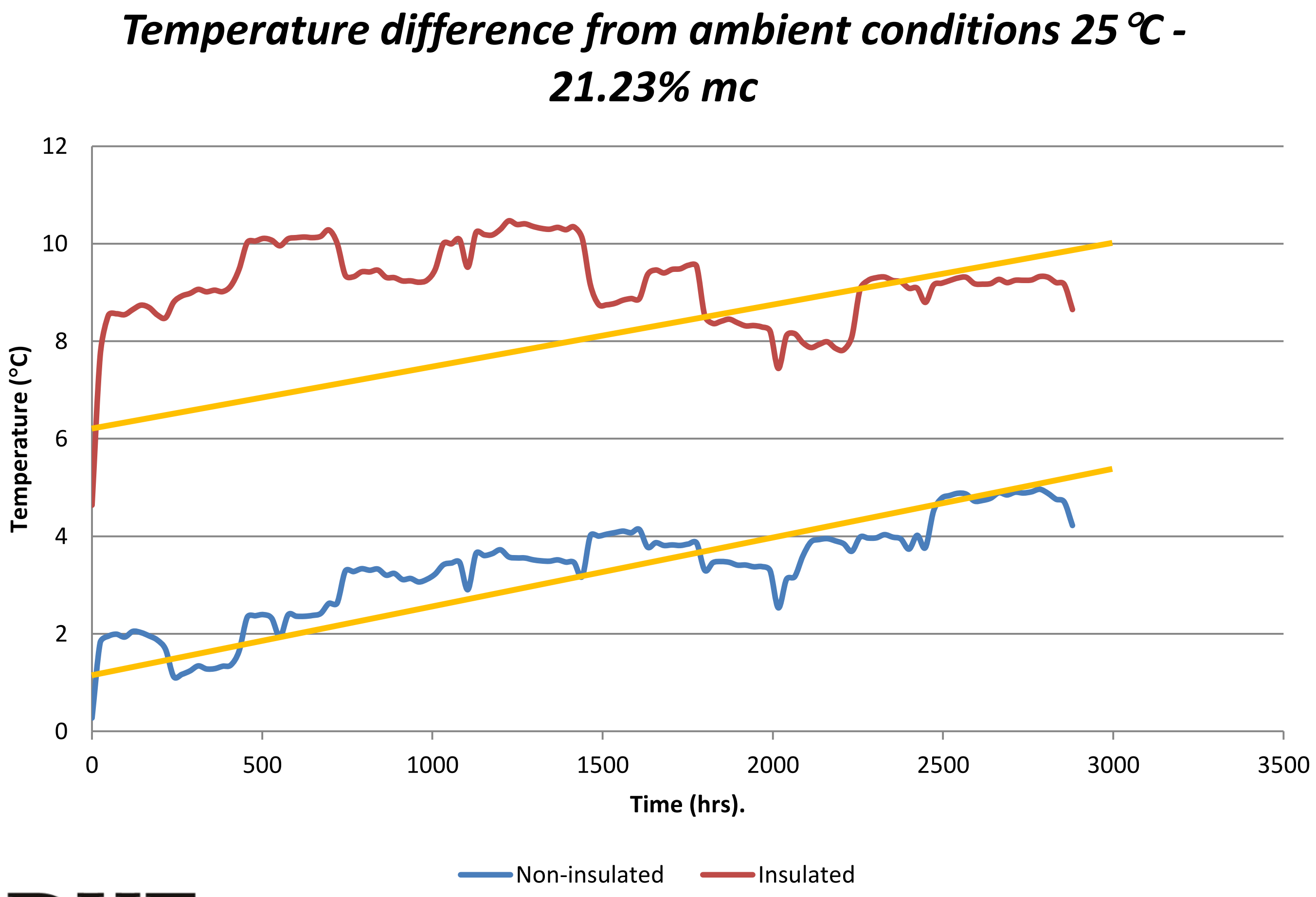
Temperature – 14.60% mc



Mold counts (CFUs) - 25°C



Grain & Ambient Temp Difference



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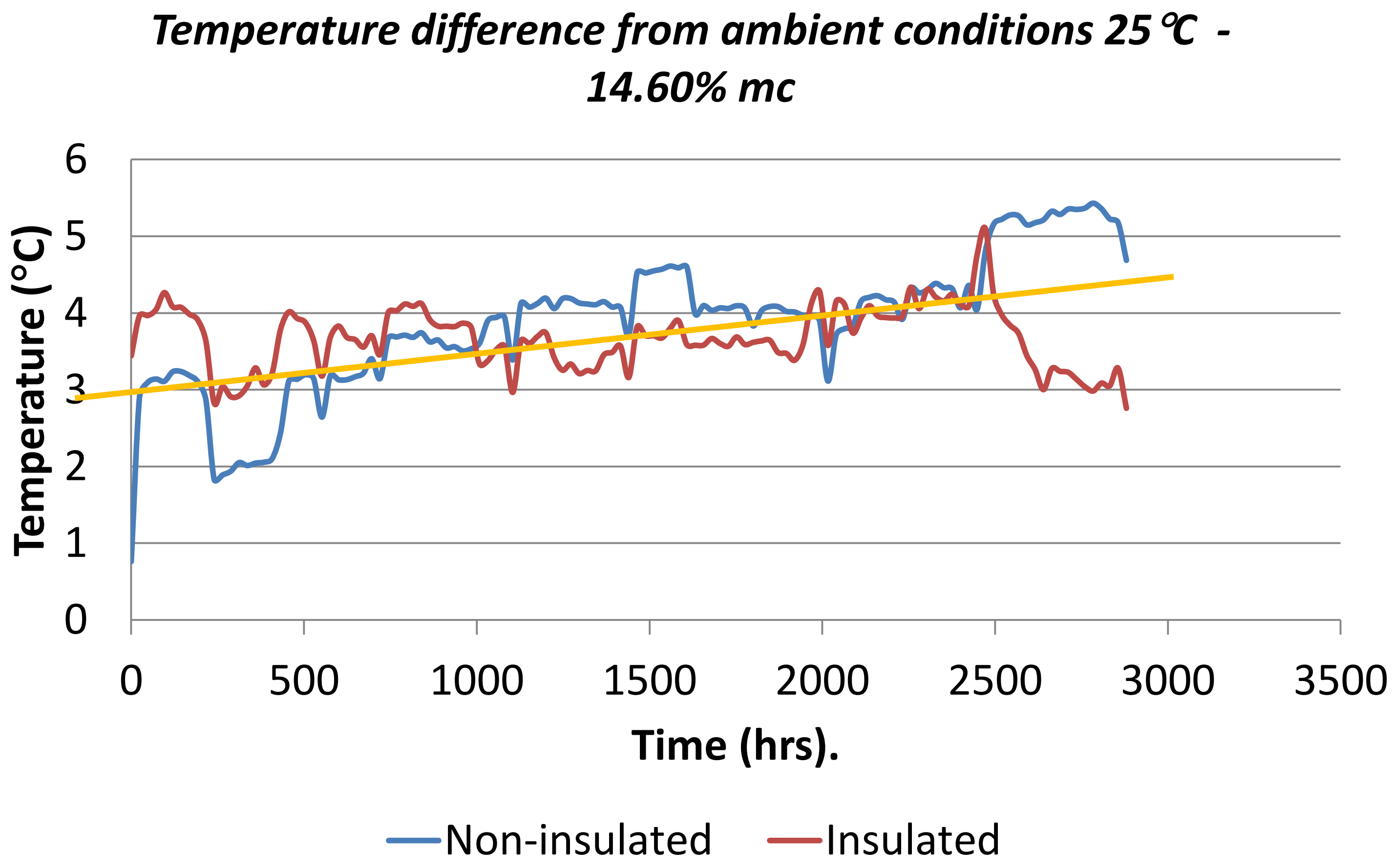
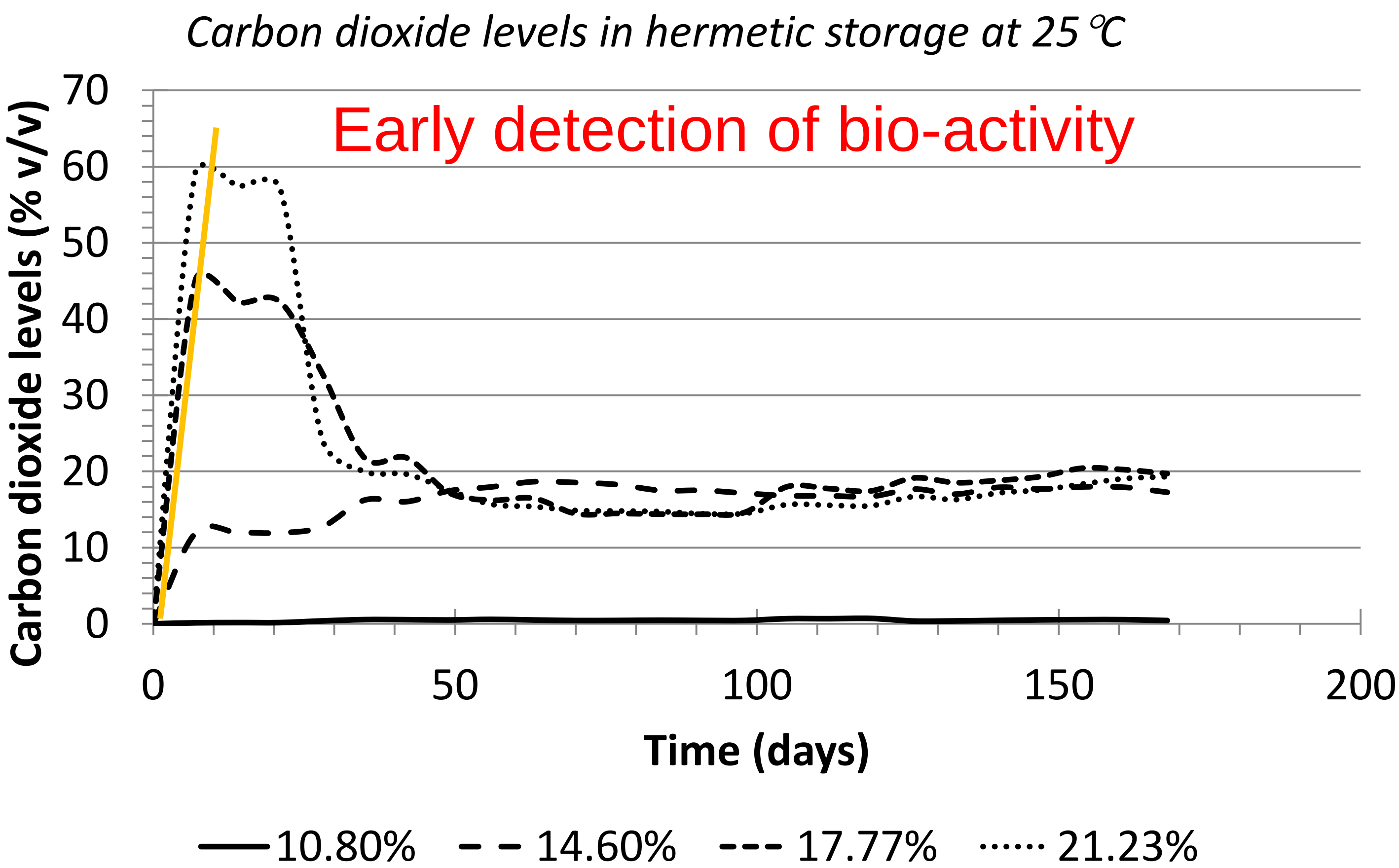
Biomass Logistics and Particle Technology Group

Grain & Ambient Temp Difference



Monitored CO_2 levels during storage



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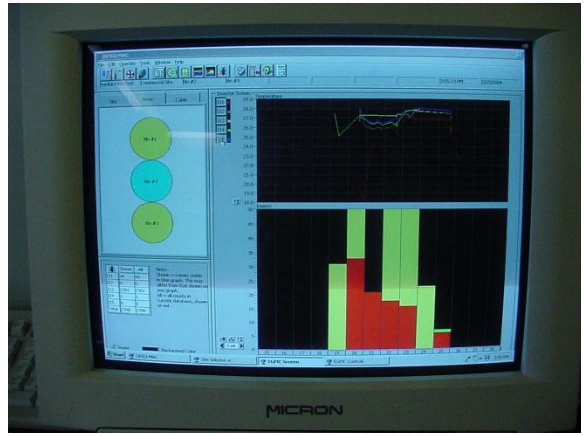
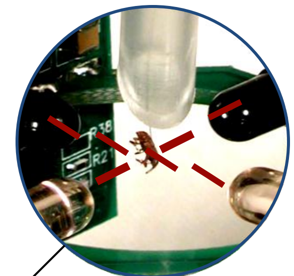
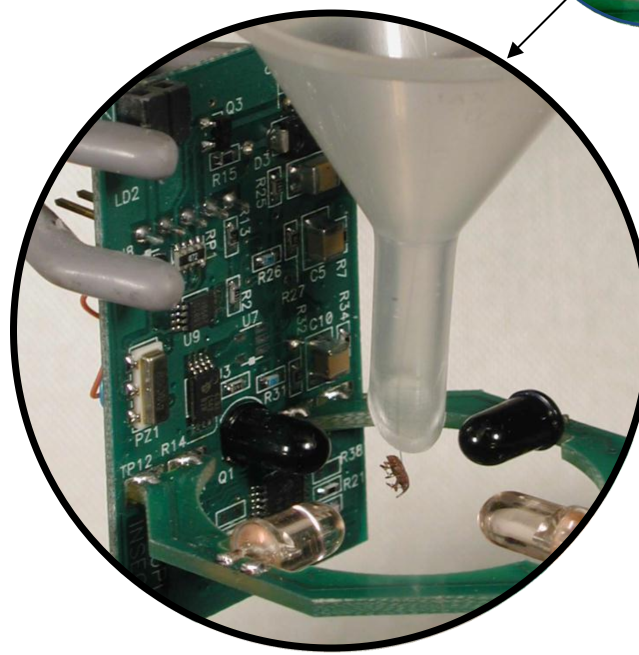
Insect Monitoring – Pitfall trap

Real-time Insect Detection System



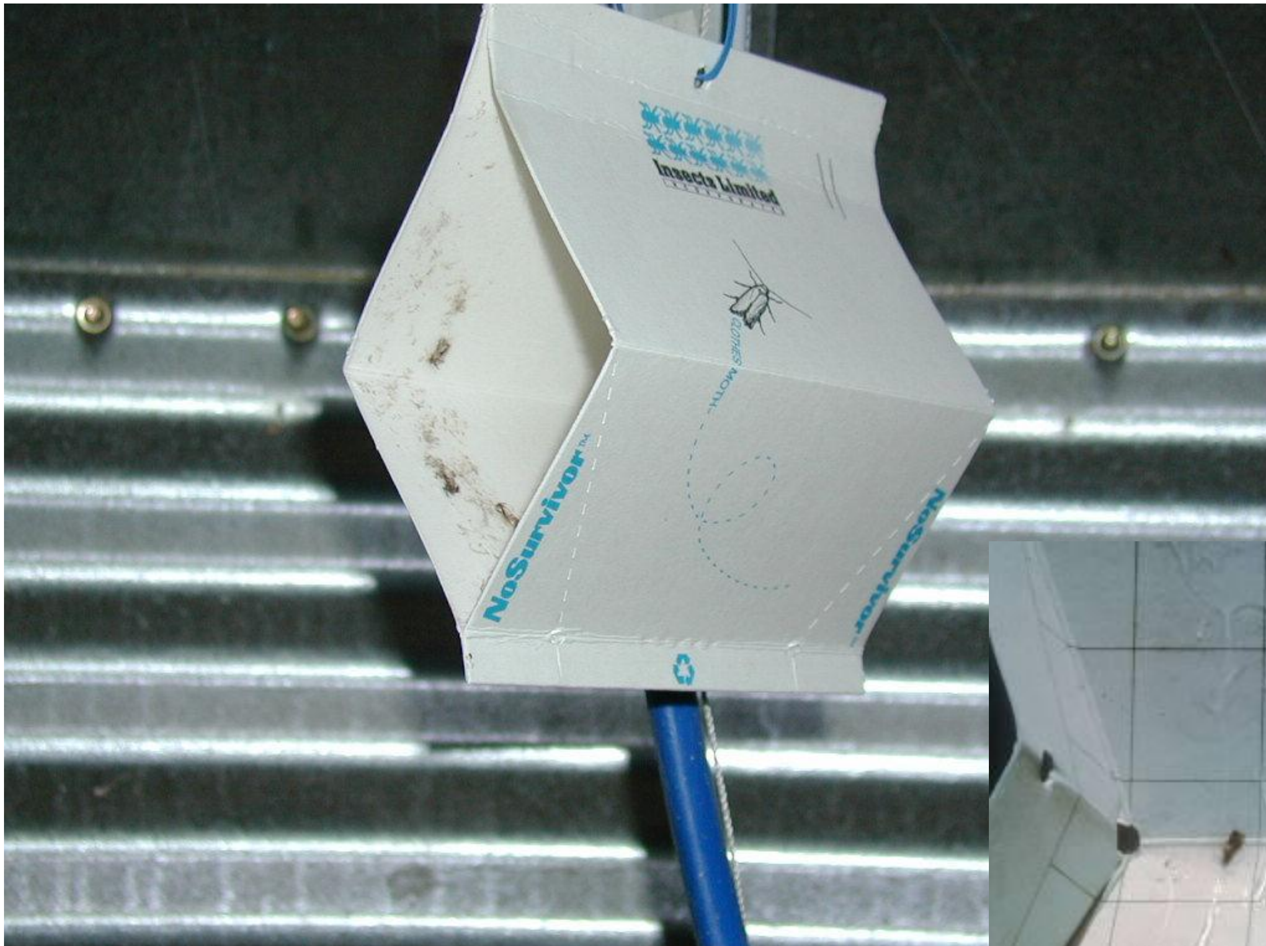
As the insect breaks the Infrared beams, its size is registered. At the same time, the time and temperature is captured in the memory on the built-in microprocessor.

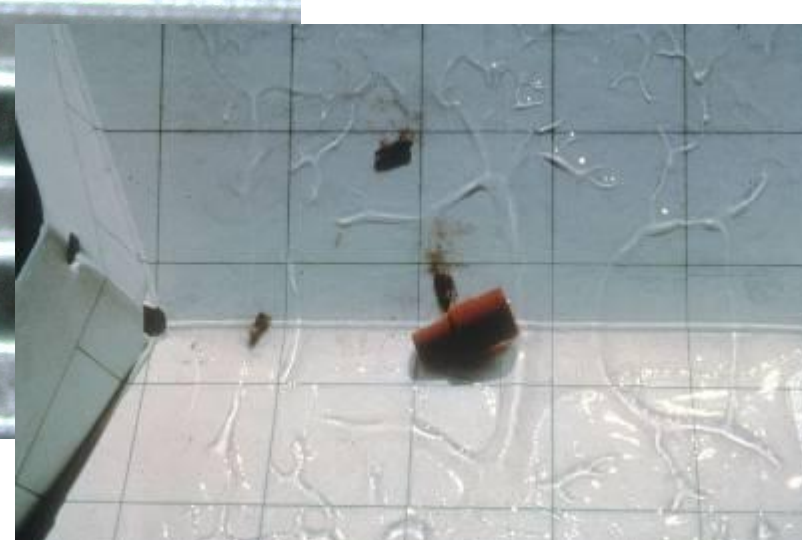




Available from:
www.opisystems.com/
Integris USA, LLC.

Insect monitoring - Pheromone flight trap





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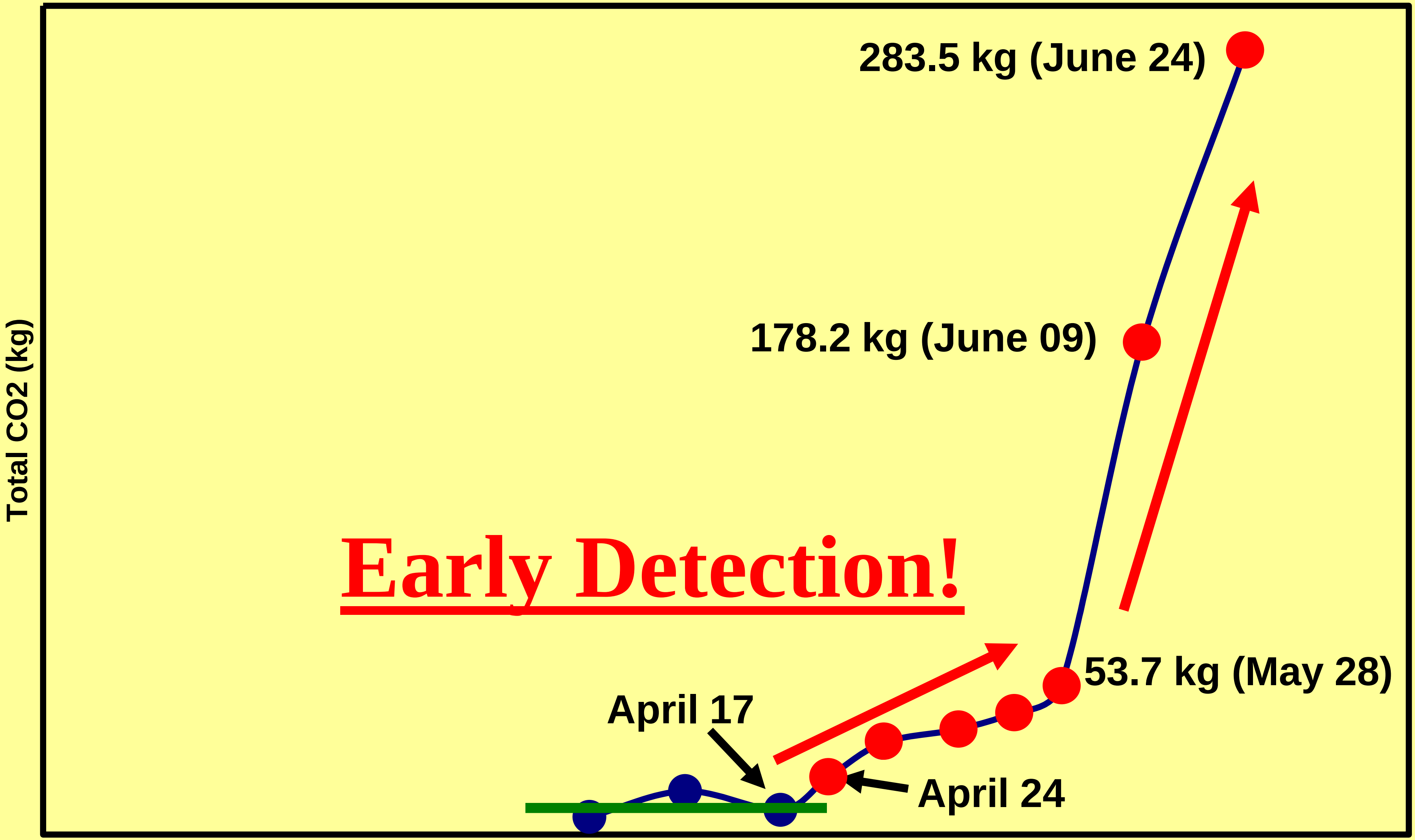
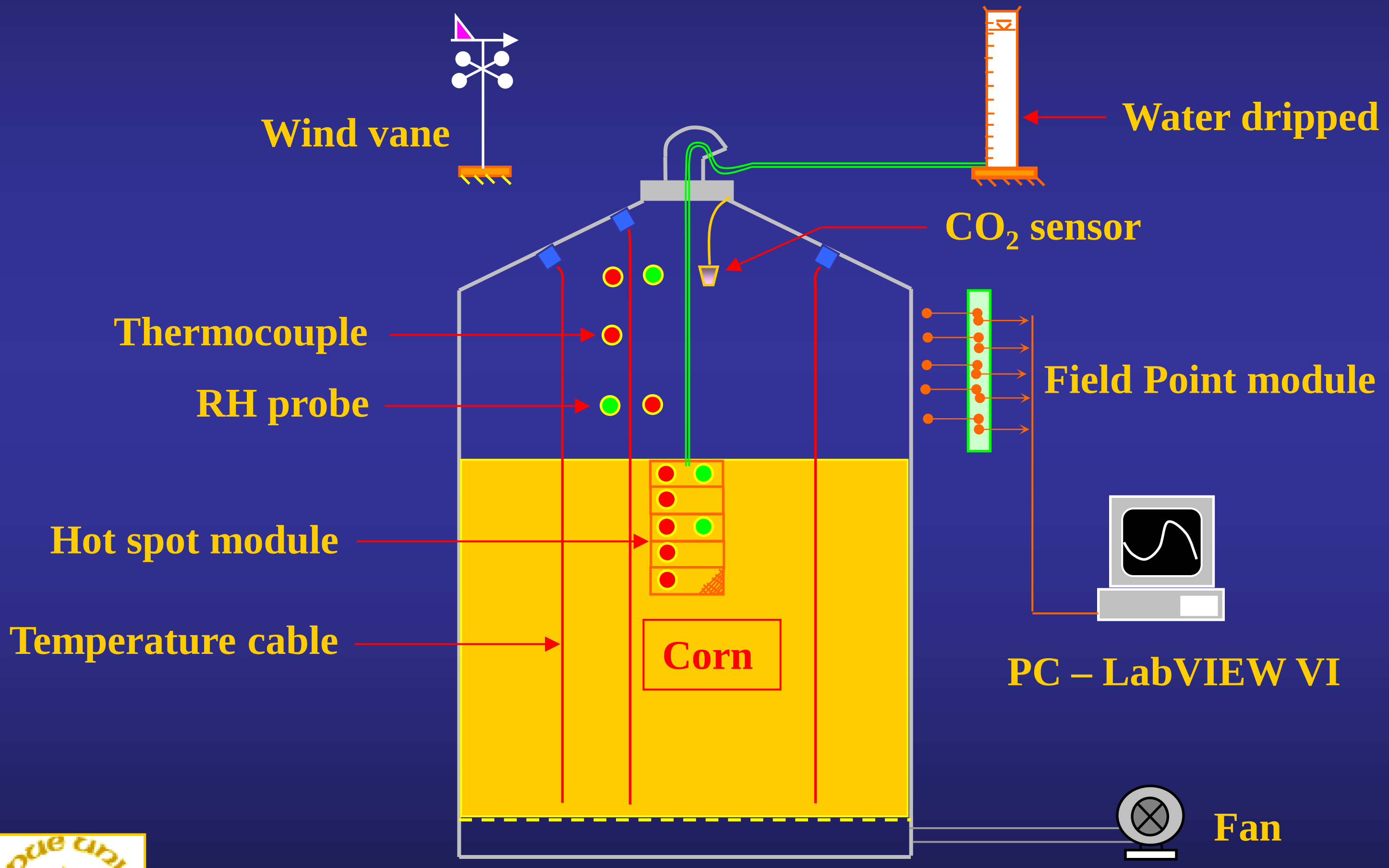
CO_2 Monitors – Early Spoilage Dectection

The Andersons, Delphi - Tank 54 (Semi-wet 17.5% MC)
Total CO_2 (kg)

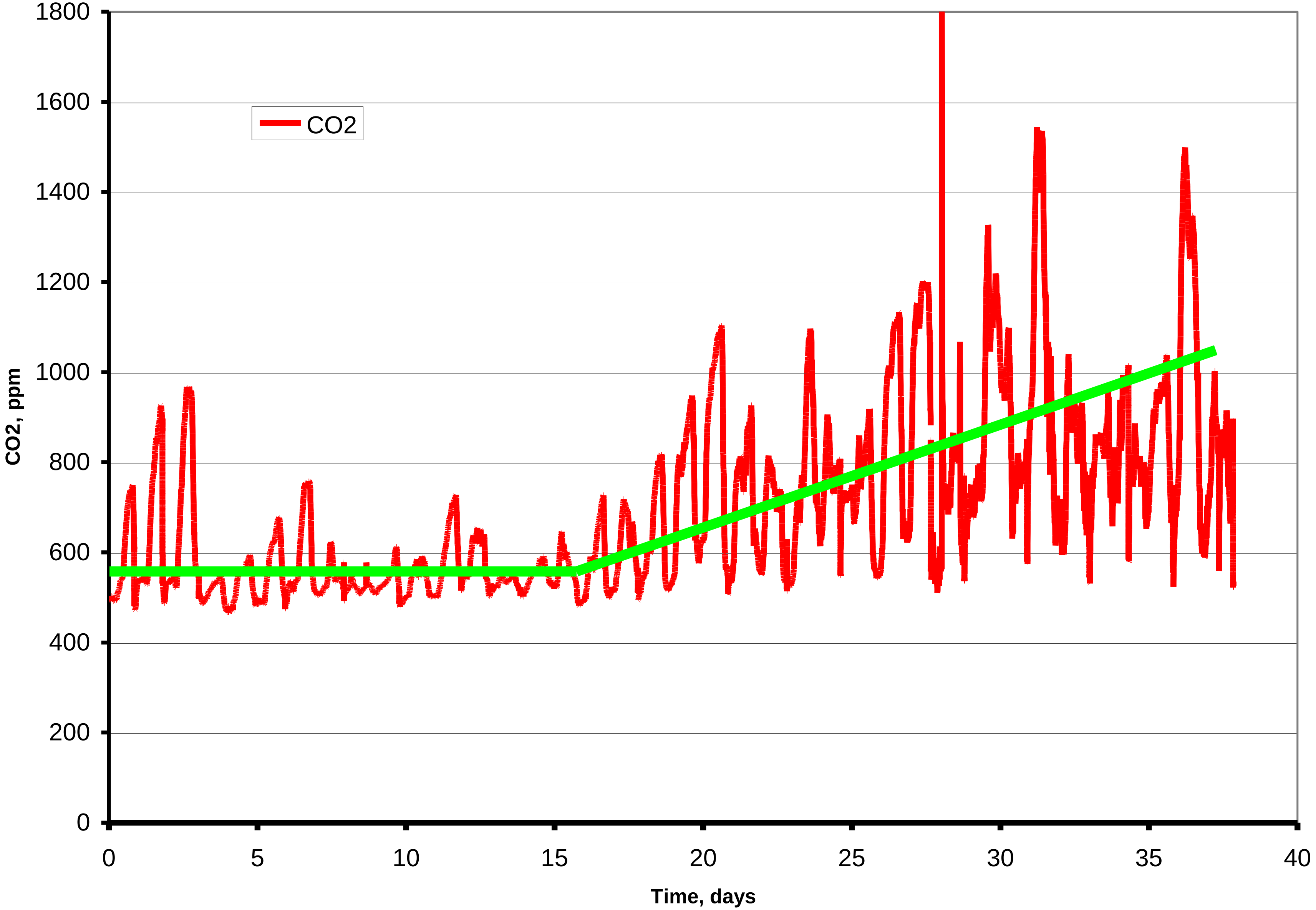


Spoilage in Tank 54

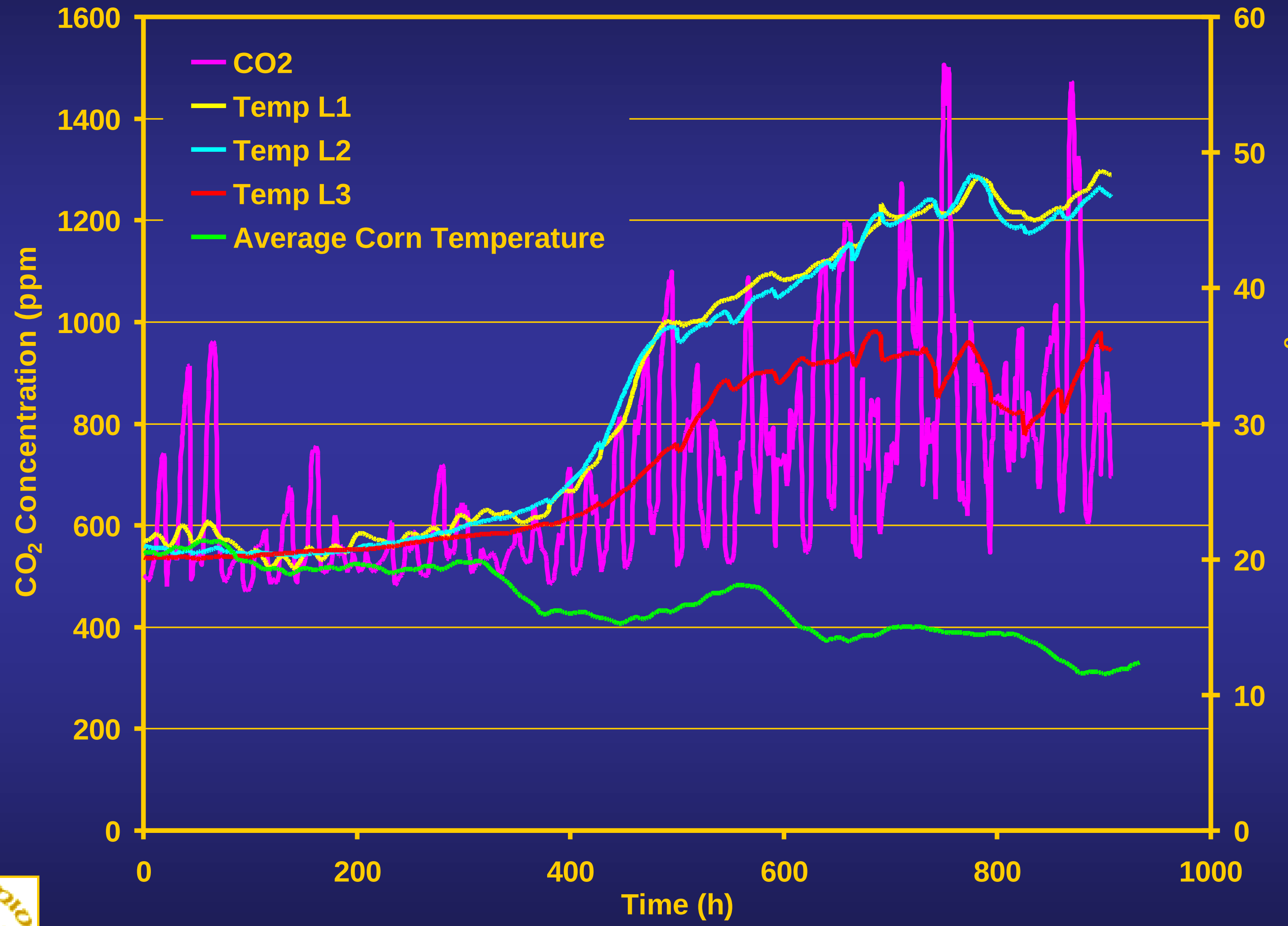
Experimental Set-up



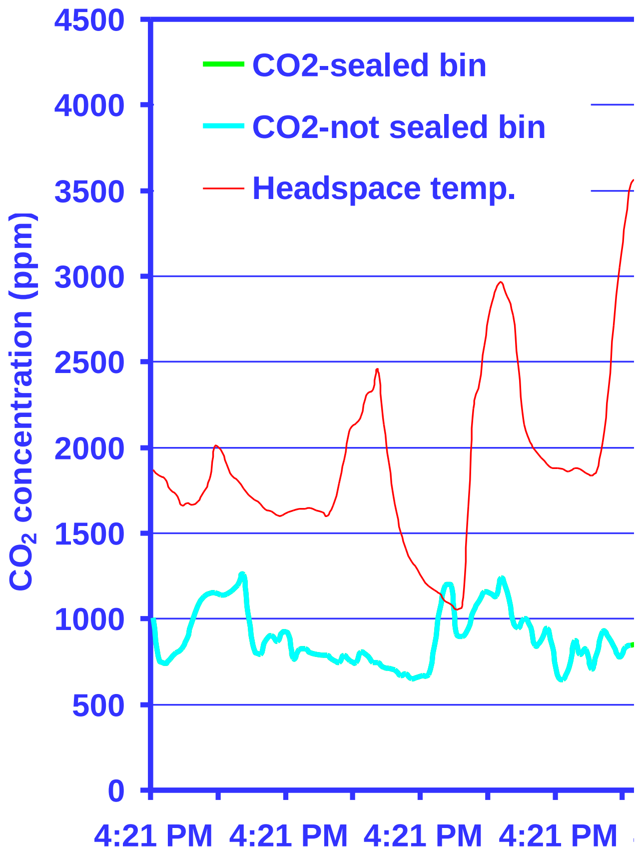
CO2 Detection during Corn Storage



CO_2 and Hot spot Temperature Data



CO_2 concentration in the headspace of PHERC pilot bin 16 due to a hot spot (10/27/01-11/5/01)



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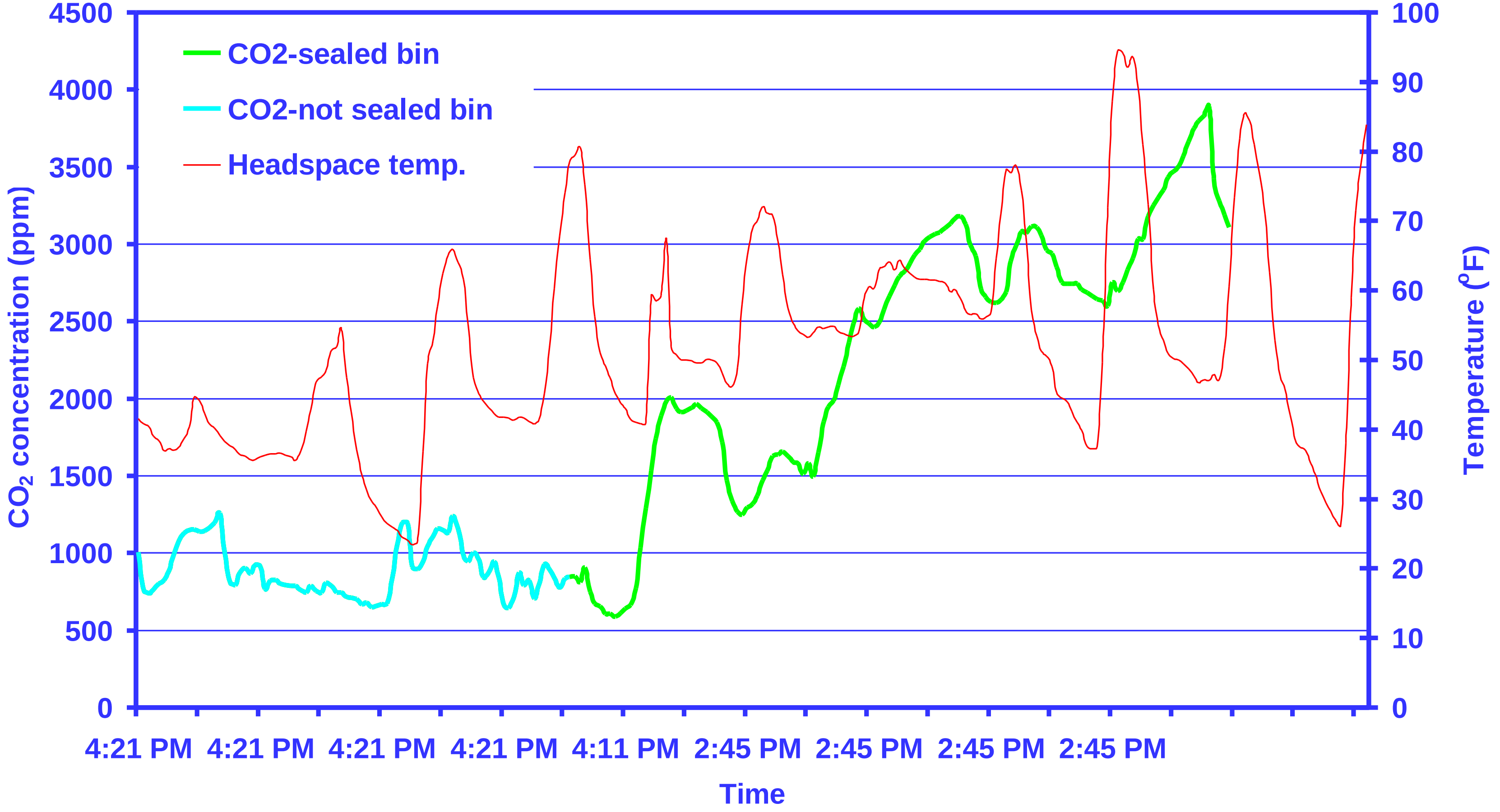


Hot spot core at the center of bin 16 caused by leakage

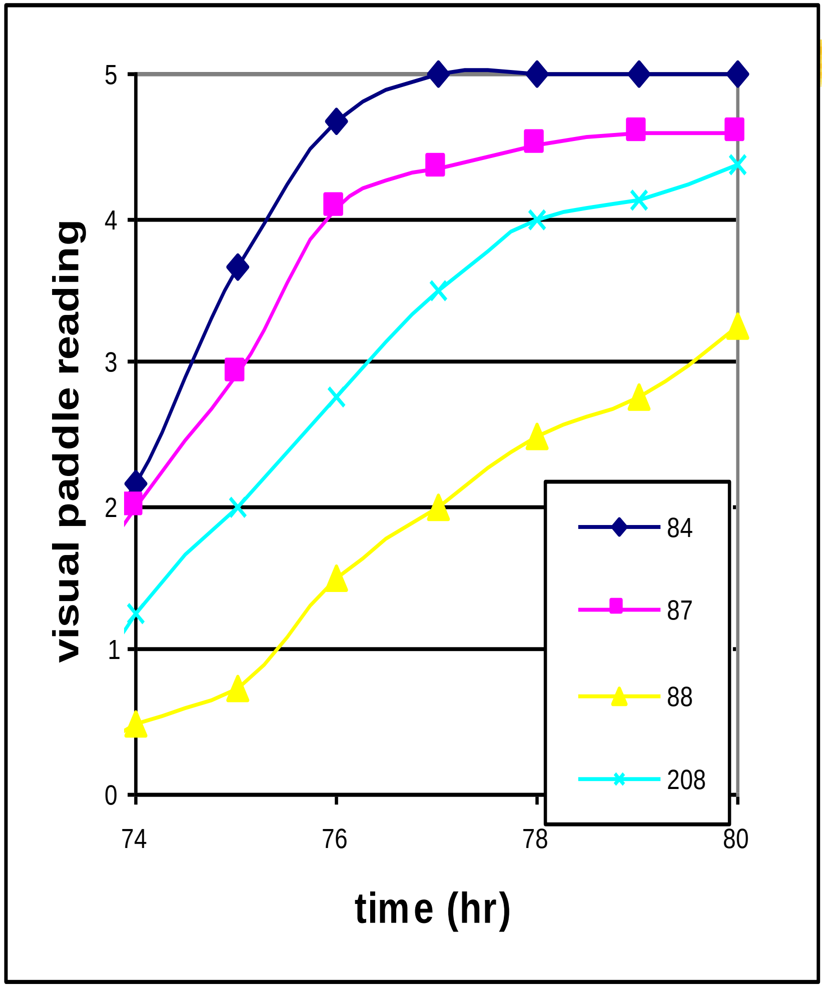
Grain Susceptibility to Spoilage Test

CO_2 Test Methods

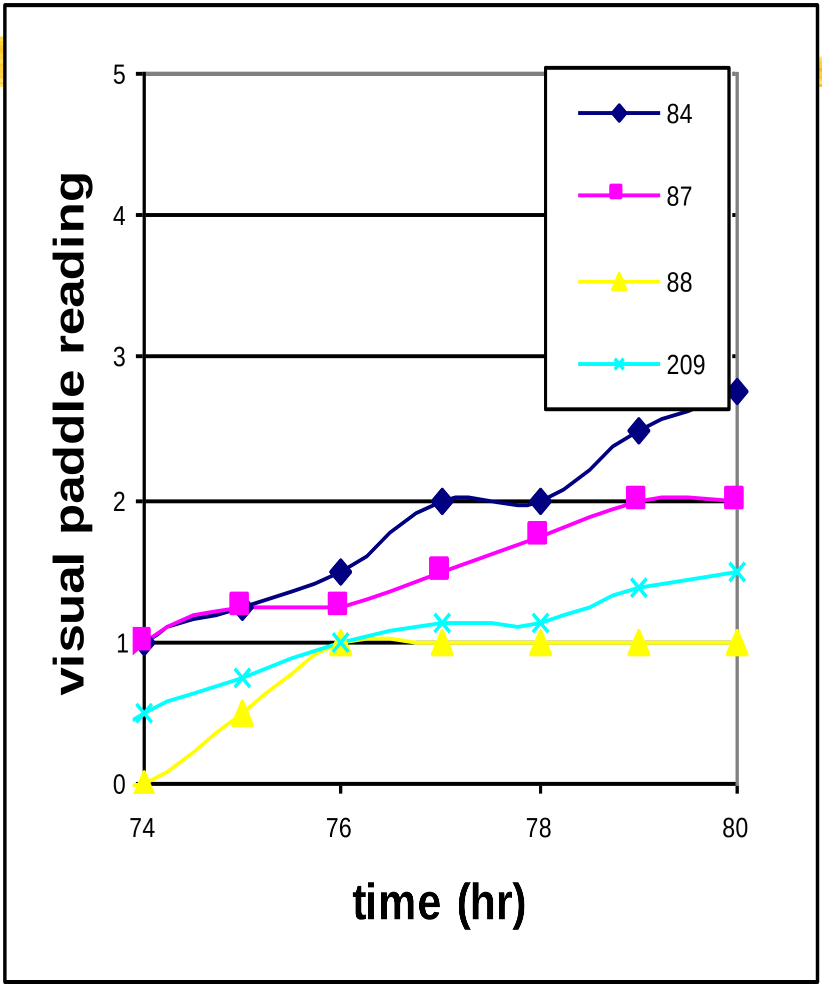
- Re-wetting (24 hr equilibration):
  - to 21% moisture
  - to 16% moisture
- Place in 1 pint air-tight jars
- Incubate at 23°C or 30°C
- 47 & 72 hrs, remove lid for 1 hr
- 48 & 72 hrs, insert indicator paddles, read hourly (color cards, DCR)
- Final Moisture content
- Dry remainder at 30°C for ergosterol & NIR

Source: Dr. Richard Stroshine, Purdue University

MC, Temperature effects: Paddle reading at 24°C, two m.c.'s



21% mc and 24°C



16% mc and 24°C

Source: Dr. Richard Stroshine, Purdue University

Resources

Some Extension websites from U.S. Land-Grant Universities:

- http://extension.entm.purdue.edu/grainlab/
- http://www.extension.iastate.edu/Grain/
- http://www.oardc.ohio-state.edu/nc213/
- http://uarpp.uark.edu/personnel.htm
- http://entoplp.okstate.edu/sprec/index.htm

Acknowledgements

- Acknowledge USDA RAMP (2001-2003) and NC-213 (2001-2002) for support in the past studies conducted.
- Thanks to The Andersons LLC Delphi facility, in particular, Mr. Bob Marlow for their collaboration over the years in conducting the CO_2 early detection study.

Thank You!
Questions?

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