Empty Bin Heat Treatments

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Heat treatment for pre-filling insect control in empty grain bins

Problem:

- Current chemicals recommended for pre-binning sanitation
- a chemical-free method of pre-filling sanitation of grain storage bins is needed
- Bins with full drying floor are particularly difficult for sanitation.

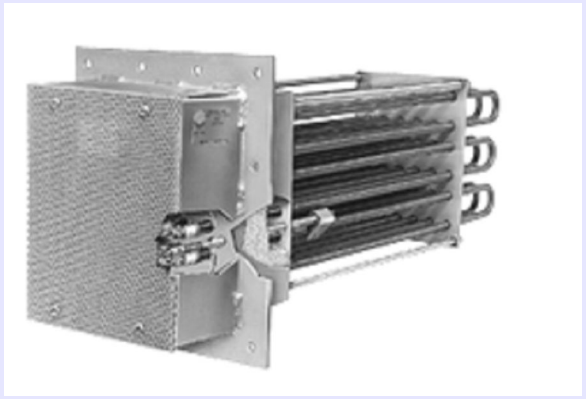
Solution:

- Heat treatment has been successfully applied in processing facilities.
- Developed heat treatment system for pre-filling insect control in empty grain bins.

Outline

- Field Tests
  - Electric heaters
  - Propane heaters
- Economic analysis
- Heat distribution issues
- Issues with fines/dust under floor
- Conclusions from our research

Field Tests – heating equipment



Duct Heater

18 kW or 61,400 BTU

Forced Air Propane Heaters

65,000 - 85,000 - 100,000 BTU

Field Tests – species in bioassays

Rice weevil
(*Sitophilus oryzae*)

Red flour beetle
(*Tribolium castaneum*)

Lesser grain borer
(*Rhyzopertha dominica*)

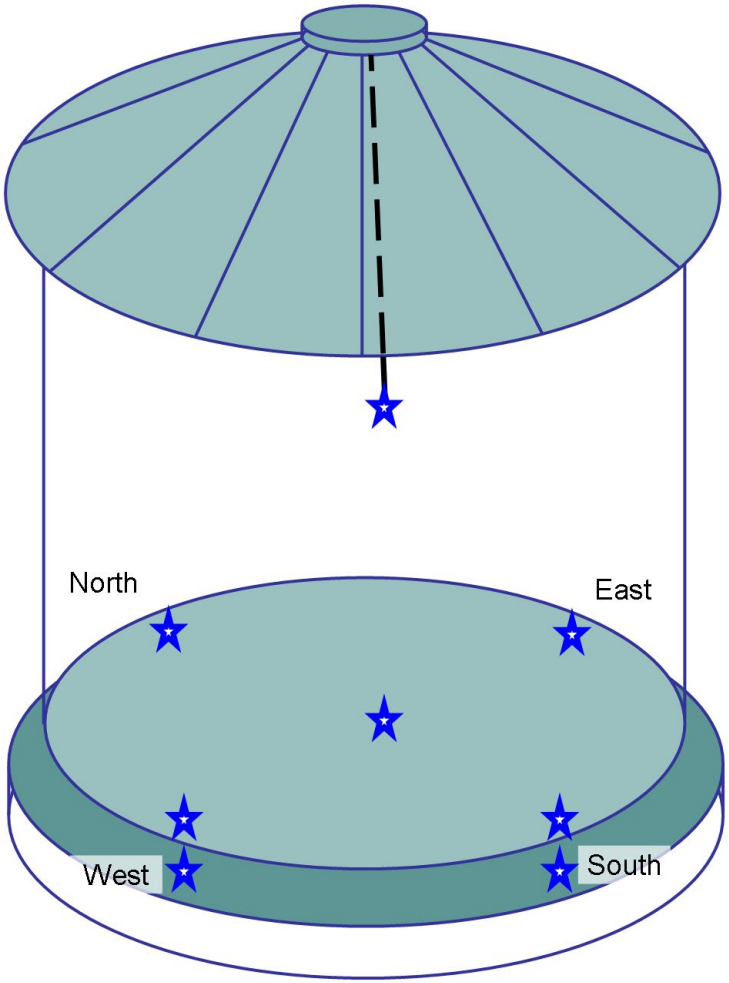
Bioassays

* 3 species of insects.

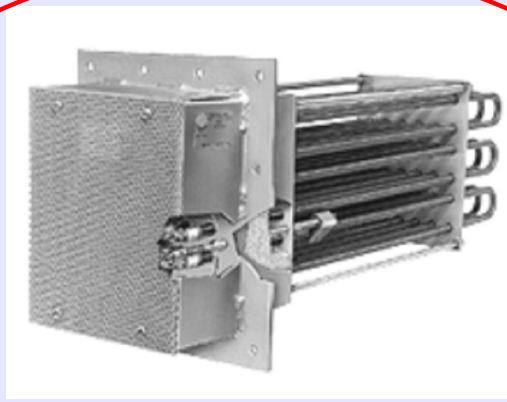
* HOBO Temperature Instrument.

* 1 tsp of cracked wheat

Field Tests – bioassay locations



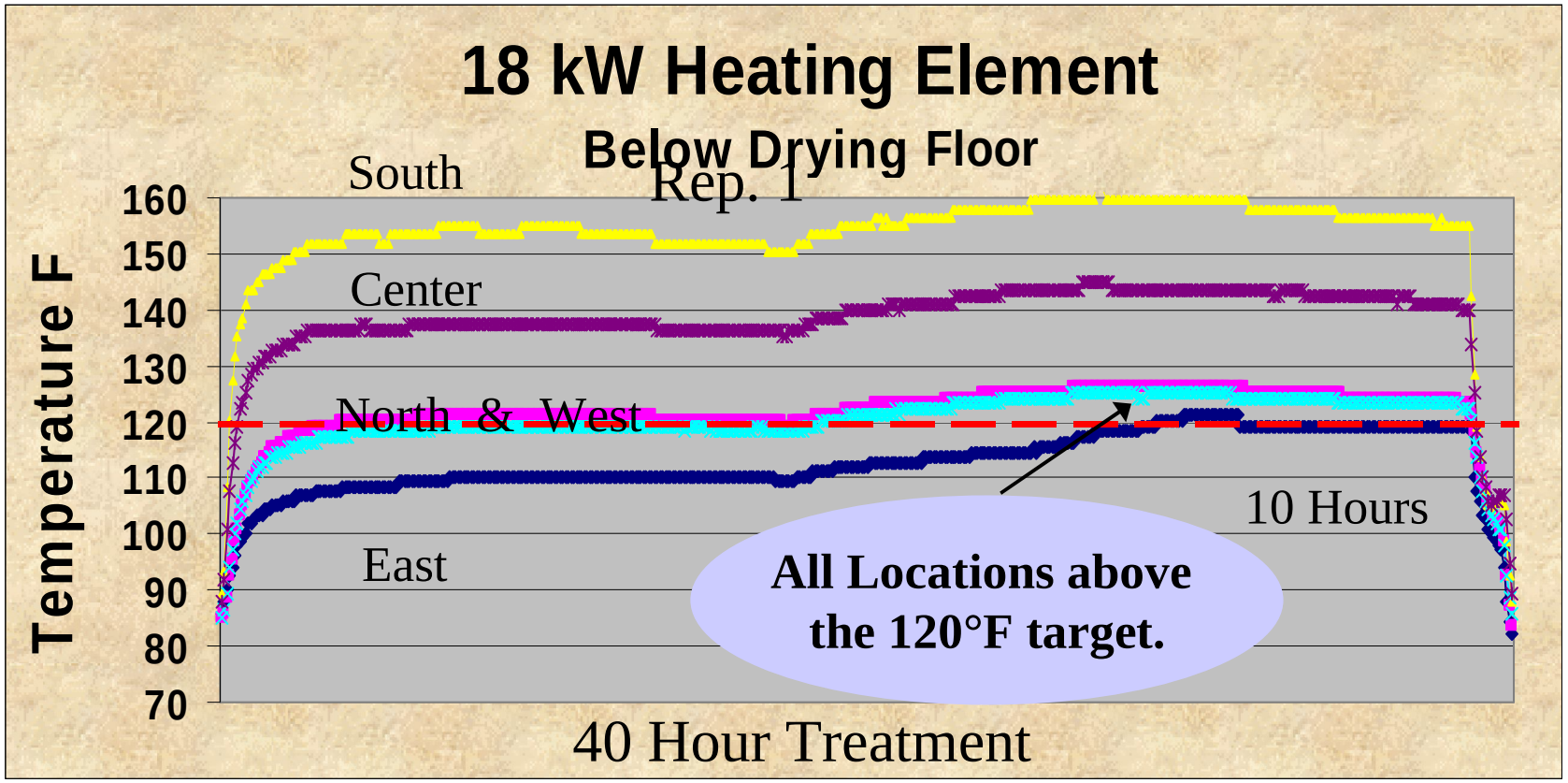
Tests with electric heaters



Duct Heater

Forced Air Propane Heaters

65,000 - 85,000 - 100,000 BTU


18 kW Heating Element
Below Drying Floor
Rep. 1
South
Center
North & West
East
Temperature F
160
150
140
130
120
110
100
90
80
70
10 Hours
All Locations above the 120°F target.
40 Hour Treatment

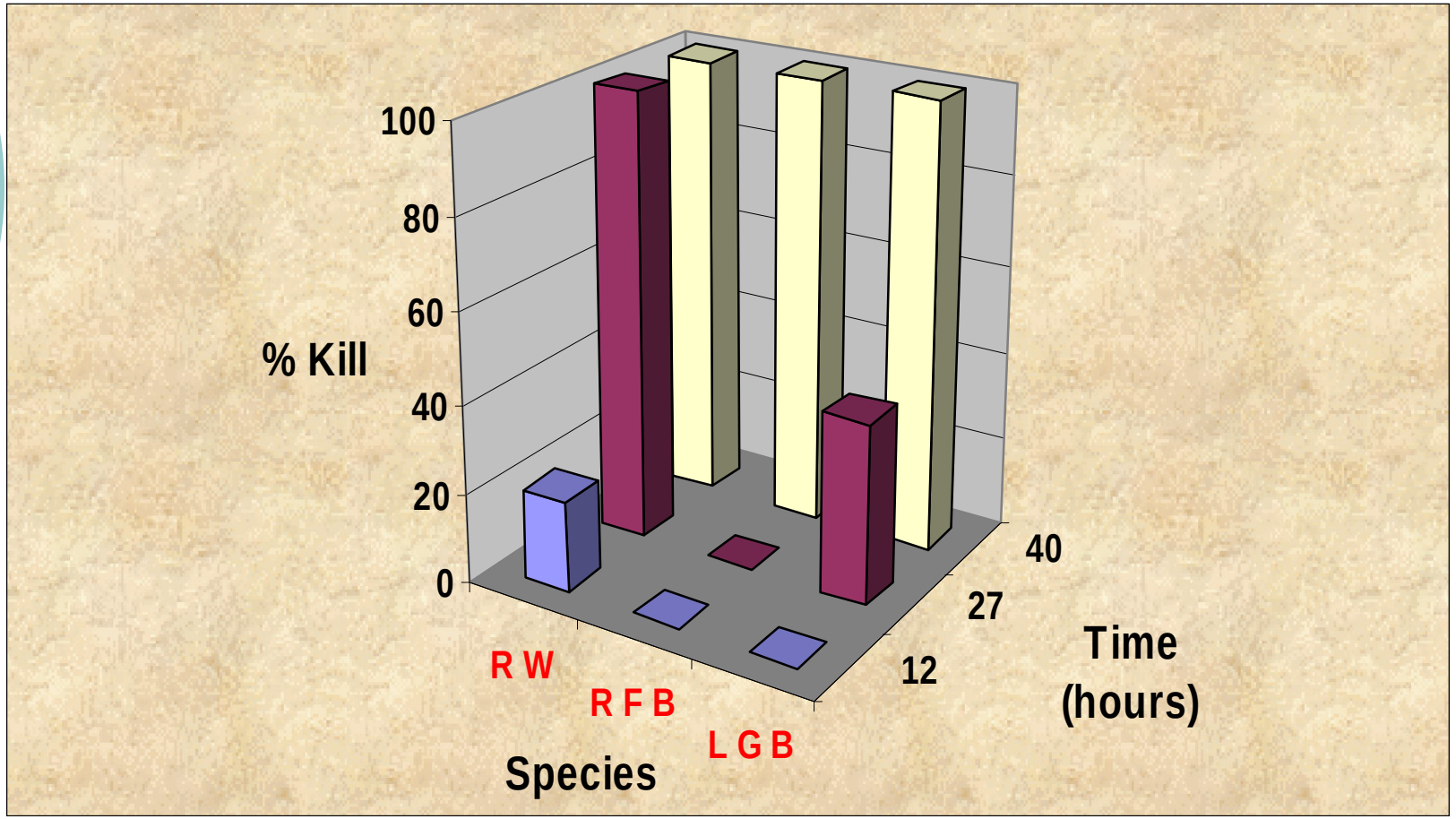
100 % Kill

Larvae exiting bin

18 kW Heating Element

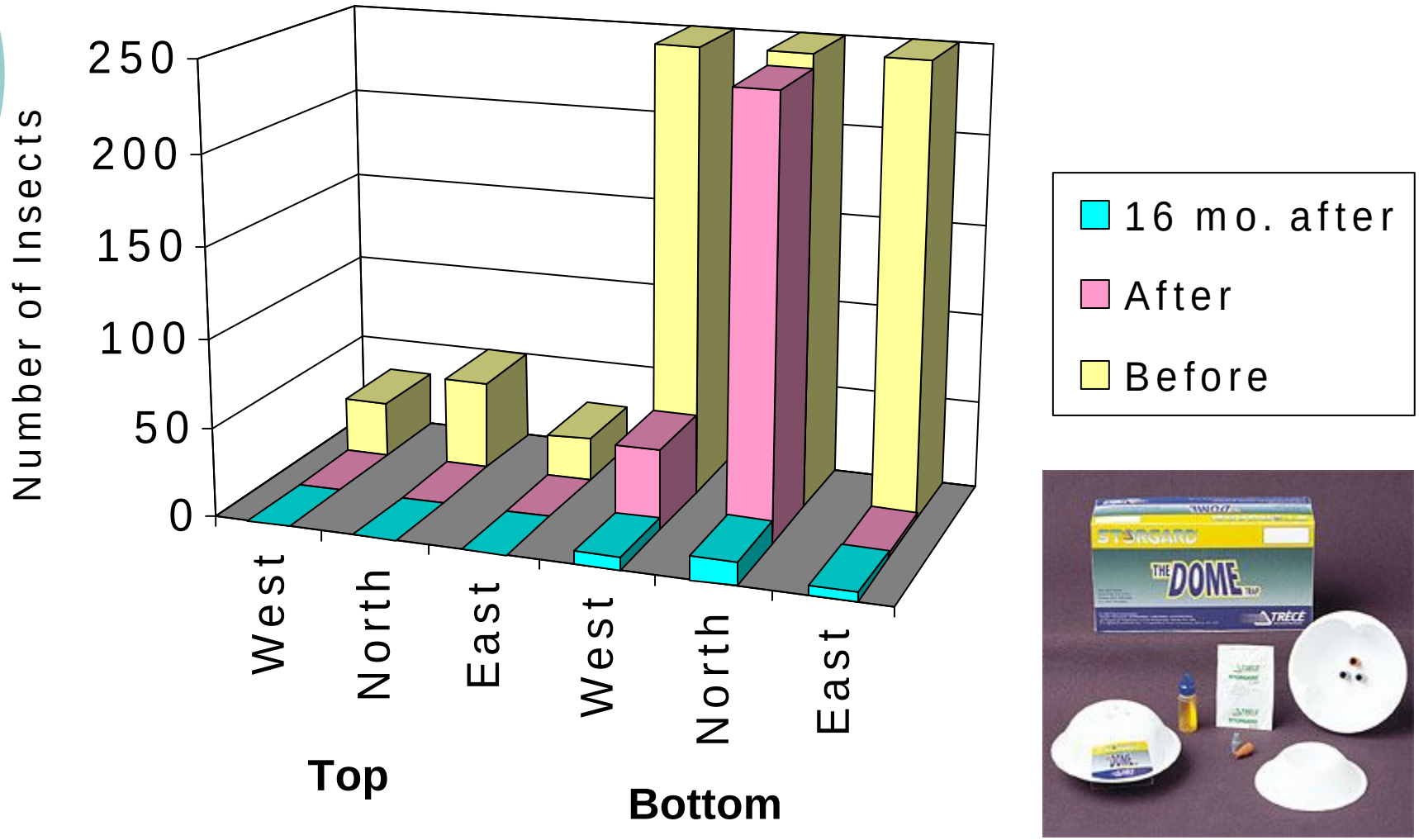
Summary of Kill Results:

Below Floor on the North Side



Trap Counts

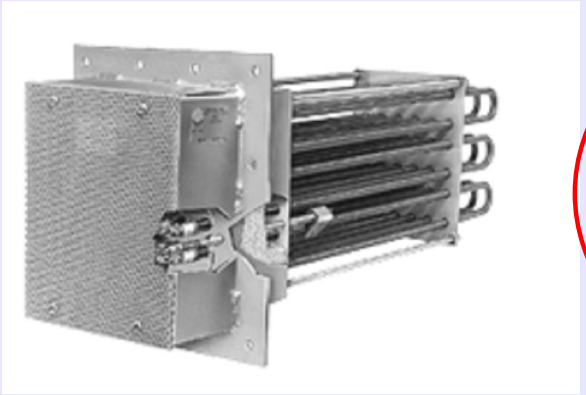
18 kW Heating Element 40 Hour Treatment



Results with electric heaters

- Relatively difficult to implement
- Difficult to achieve 100% mortality
- Reason: existing electric power on-farm typically wasn't sufficient (requires bringing in auxiliary power)

Tests with propane heaters



Duct Heater

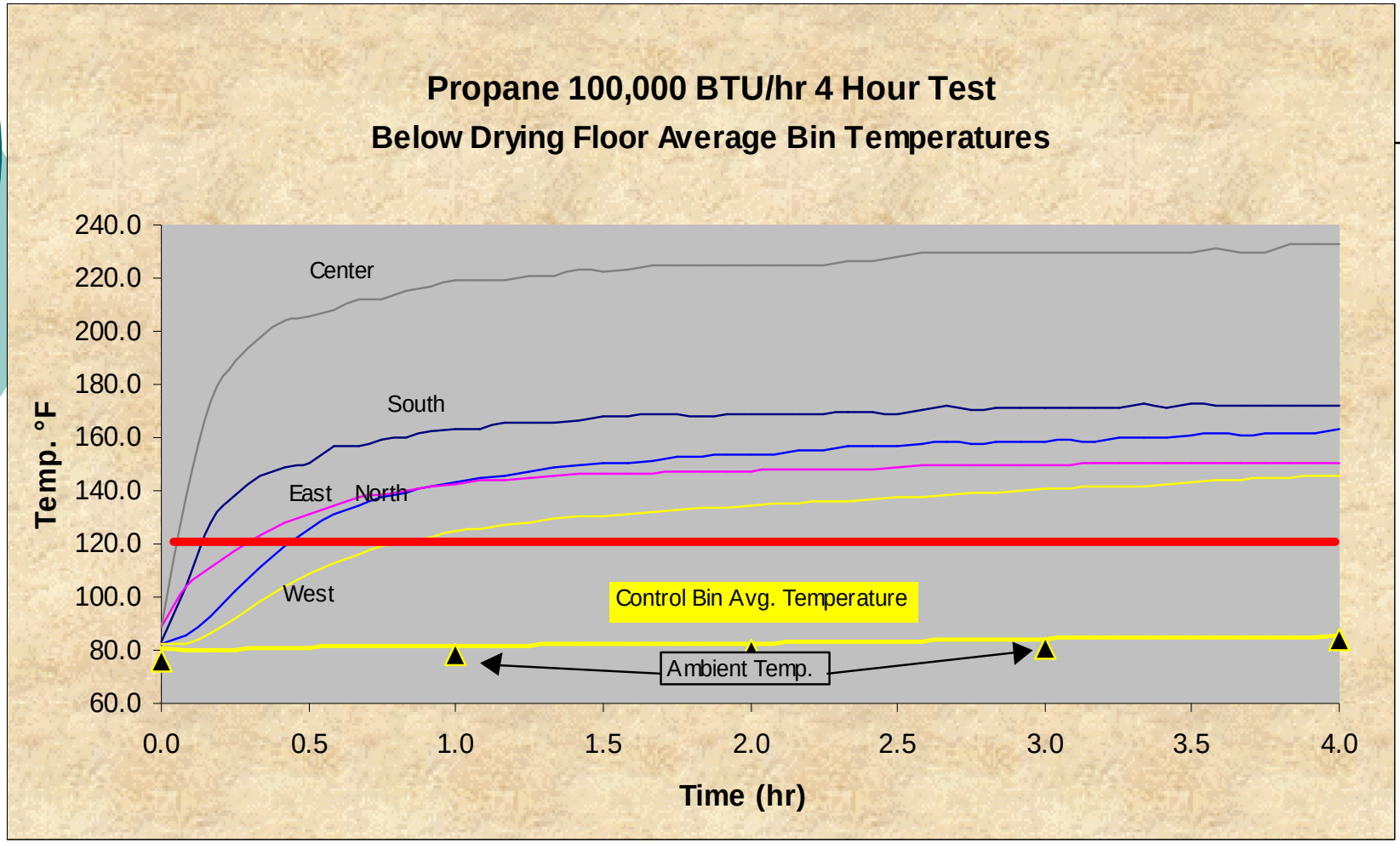
Forced Air Propane Heaters

65,000 - 85,000 - 100,000 BTU

Propane heater field tests

100,000 Btu/hr Propane heater

Bin Wall


Propane 100,000 BTU/hr 4 Hour Test
Below Drying Floor Average Bin Temperatures
Temp. °F
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Time (hr)
Center
South
East
North
West
Control Bin Avg. Temperature
Ambient Temp.

100 % Kill

Results with propane heaters

- Relatively easy to implement
- Achieved 100% mortality in < 2 h
- Reason: relatively easy to apply sufficient heating power

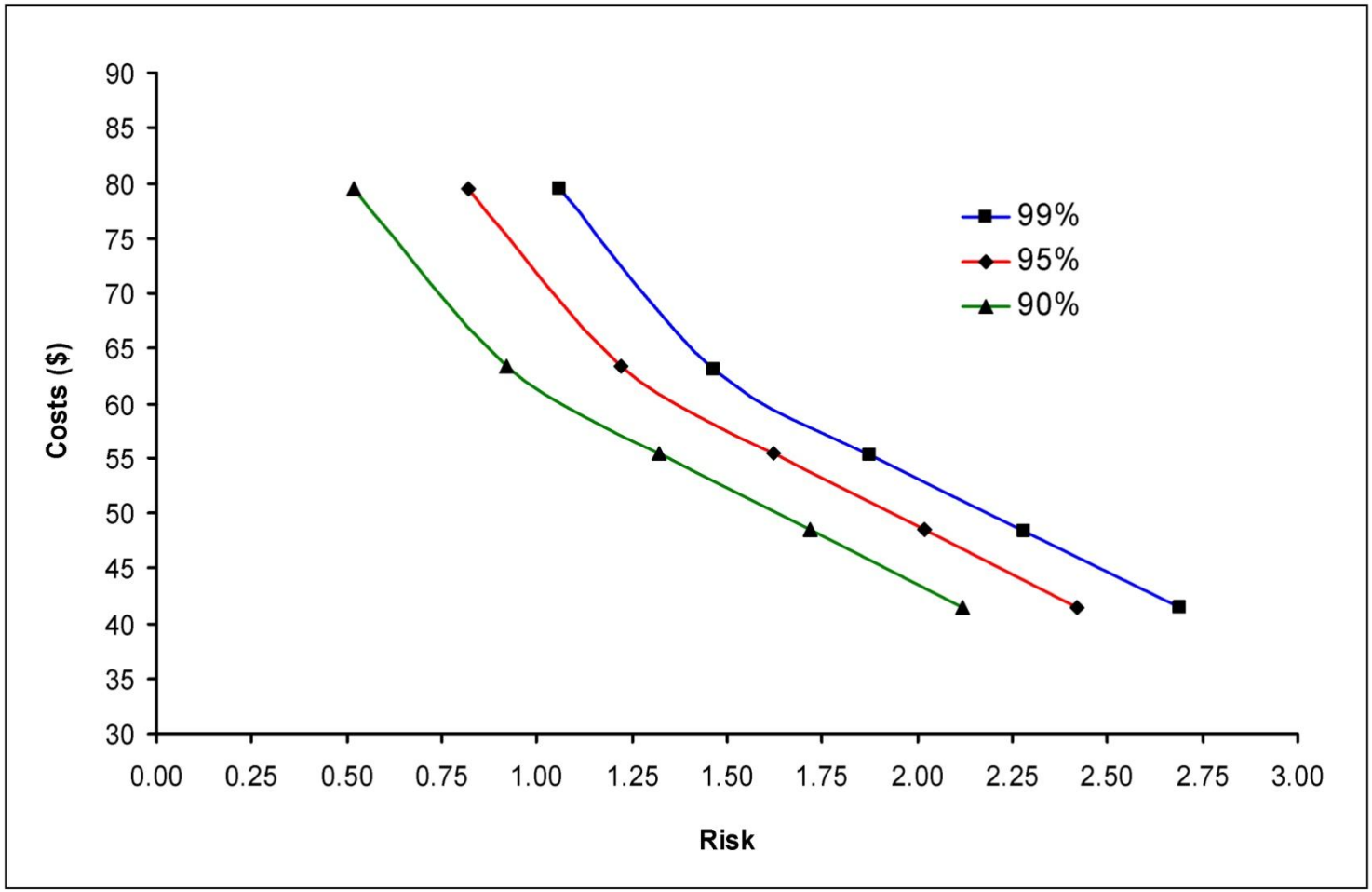
Economic Analysis

Evaluate economics of heat treatment of empty grain storage bins to provide a useful tool for decision-making by grain storage managers

Economic analysis results

- Propane system 1
  - Chemical
    - Cost effective and lowest risk levels of all nonchemical systems.
      - However, may have negative influence on the enviornment and worker safety
- Electric system 1
  - Low cost and risk levels
    - 100% mortality after 40 hours
      - Insects may develop resistence
    - High variable costs
    - Other electric systems unattractive due to high costs and increased risk levels

Risk-cost graph of three mortality-goal frontiers for Electric System 2



Heating and chemical system variable cost summary

Variable cost	Electric systems								
	Electric system 1 (18-kW)			Electric system 2 (18-kW)			Electric system 3 (15-kW)		
	12 h	27 h	40 h	12 h	27 h	40 h	12 h	27 h	40 h
Labor ($12.56/h)	50.24	50.24	50.24	25.12	25.12	25.12	25.12	25.12	25.12
Energy ($/kW·h)	16.30	36.68	54.84	16.3	36.68	54.84	13.58	30.57	45.28
Total	66.54	86.92	105.08	41.42	61.80	79.96	38.70	55.69	70.40

	Propane systems					
	Propane system 1 (29-kW)			Propane system 2 (19-kW)		
	2 h	3 h	4 h	4 h	6 h	8 h
Labor ($12.56/h)	25.12	25.12	25.12	25.12	25.12	25.12
Energy ($/kW·h)	2.75	4.12	5.50	3.50	5.25	7.00
Total	27.87	29.24	30.62	28.62	30.37	32.12

	Chemical systems	
	Solution rate 1 (9.3 ml)	Solution rate 2 (18.6 ml)
Labor ($12.56/h)	12.56	12.56
Chemical solution	1.09	2.18
Total	13.65	14.74

Economic modeling summary

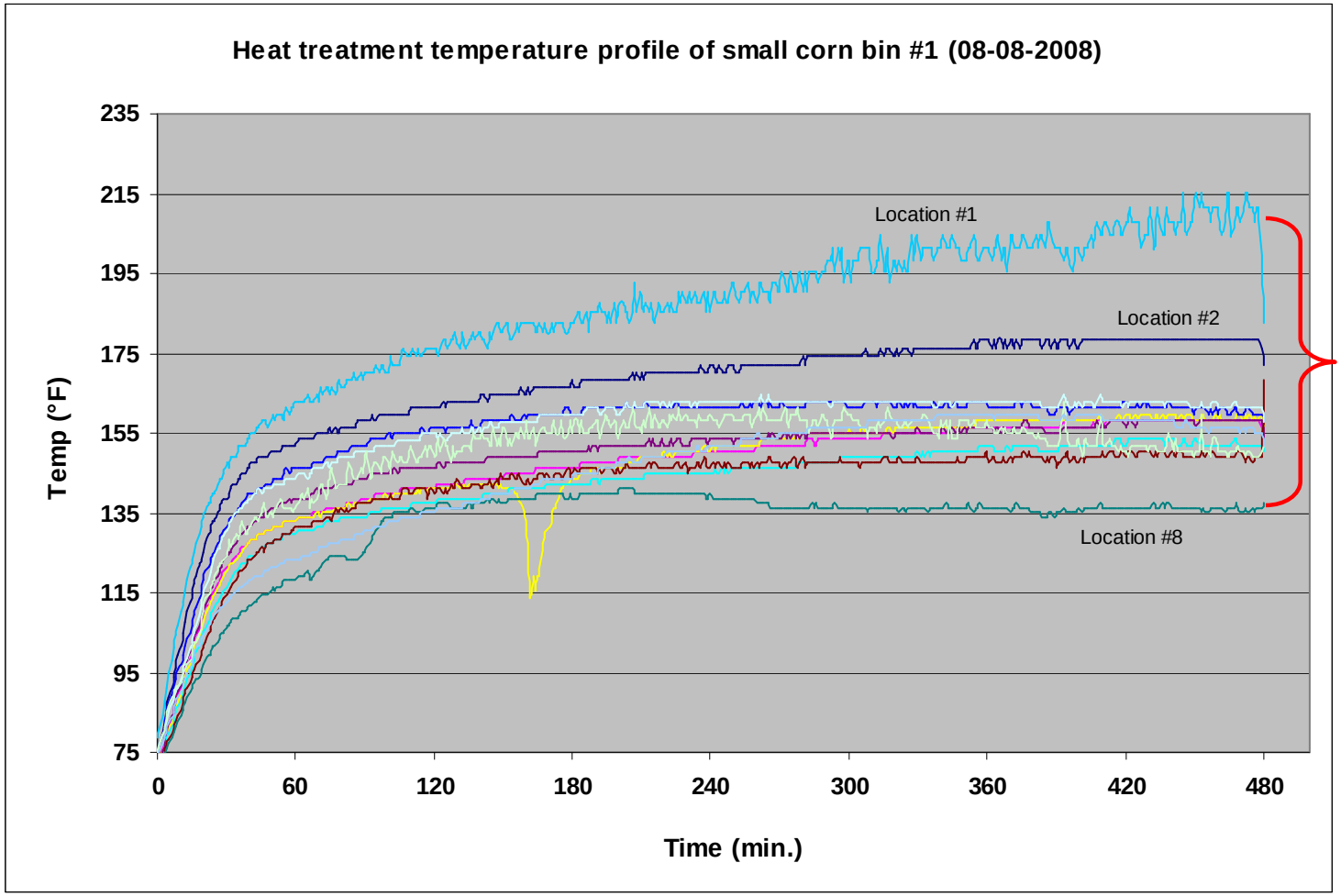
The empirical model could easily be adapted by other researchers or decision makers interested in trade-off between cost and insect mortality.

Heat distribution issues

Evaluate the effect of non-uniform heating under the bin drying floor

Below bin floor structural supports

Maximum non-uniform heating



Temperatures around bin periphery

	Location					
Hour	1	2	5	8	10	12
2	82.3	73.7	60.1	58.9	69.5	63.8
3	85.7	76.3	62.2	59.9	72.1	65.6
4	89.2	78.1	63.8	58.4	72.8	68.1
5	93.3	79.9	65.4	57.9	72.7	68.4
6	94.9	81.0	66.4	57.6	72.5	68.2
7	98.1	81.2	67.0	57.9	72.2	67.4

Tests with insulating layer of fines

Evaluate the effect of grain dust covering on insect survival during heat treatment

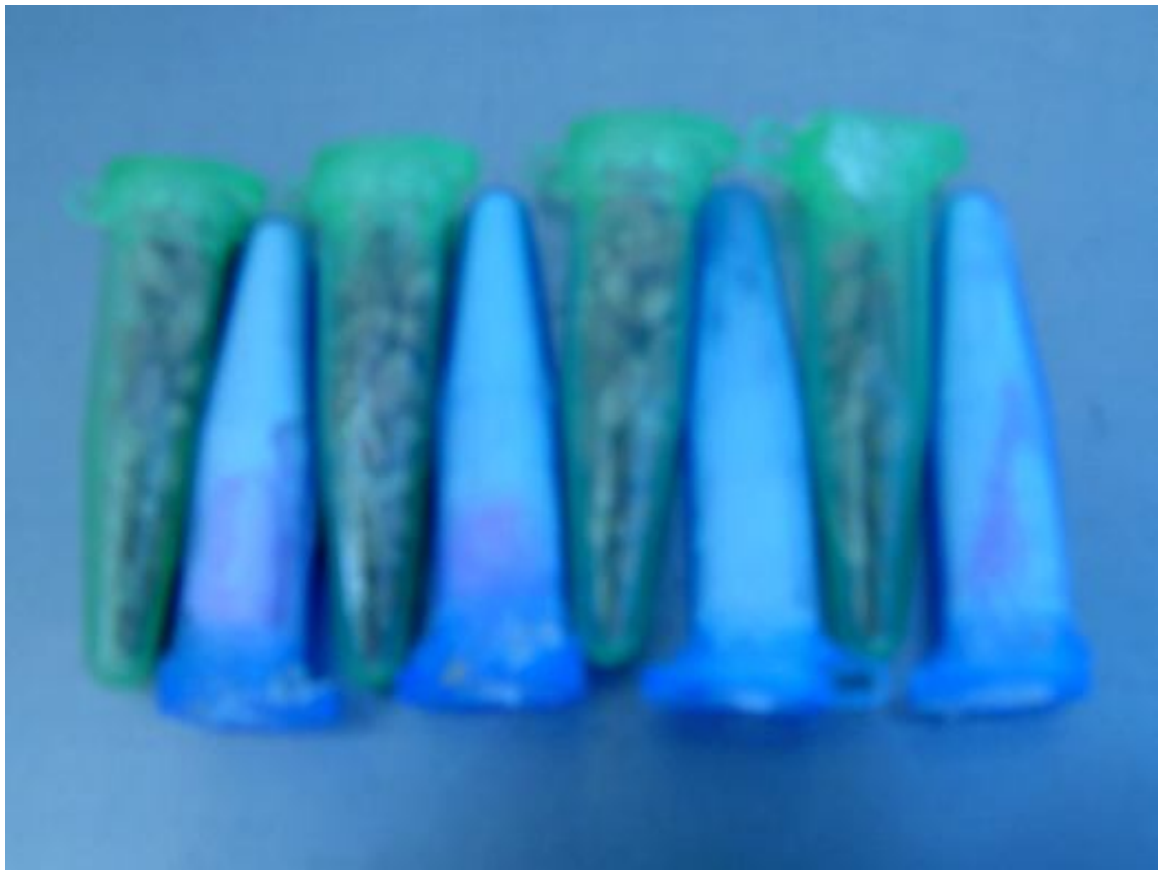
Fines colle

Perforations

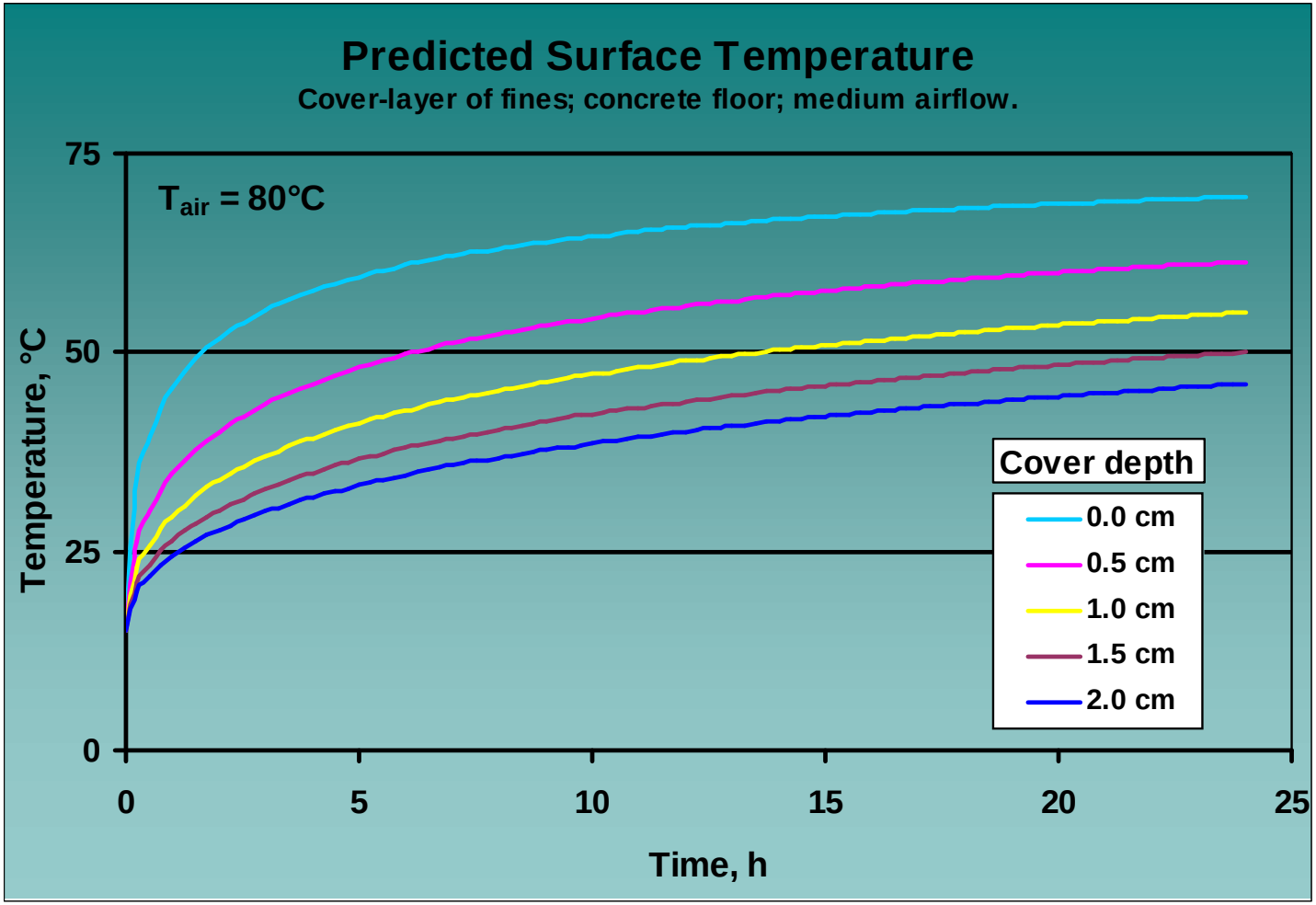
Fines

Bioassay arrangement used to study cover layer effects

Bioassay vials



Effect of grain dust covering on insect survival during heat treatment



Conclusion

- Heat treatment can be effective for sanitizing steel grain bins prior to filling.
- Potential problems to overcome:
  - non-uniform heat distribution in the plenum.
  - insects surviving with cool shelter of concrete floor
- Solutions:
  - monitor periphery of concrete floor for cool zones (Hobos, thermocouples, temperature guns, ...)
  - increase fan size for better heat distribution
  - increase treatment temperatures and/or times to overcome concrete heat sink