

Physical Methods for Management of Stored-Product Insects

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Physical Techniques

- Temperature extremes (heat and cold)
- Modified atmospheres
- Vacuum
- Sanitation
- Traps
- **Impact**
 - Entoleters or infestation destroyers (impact machines)
 - Pneumatic conveying
- **Exclusion**
 - Insect screens
 - Door sweeps

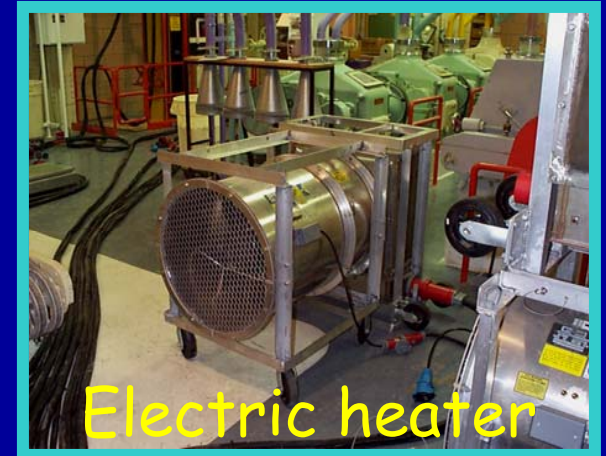
❖ Heat treatment concept: Raising the ambient air temperature of the complete or partial facility to 122-140°F (50-60°C), and maintaining these temperatures for 24 hours



Gas heaters



Steam heater



Electric heater



Duct carrying heat from gas heaters



Fan

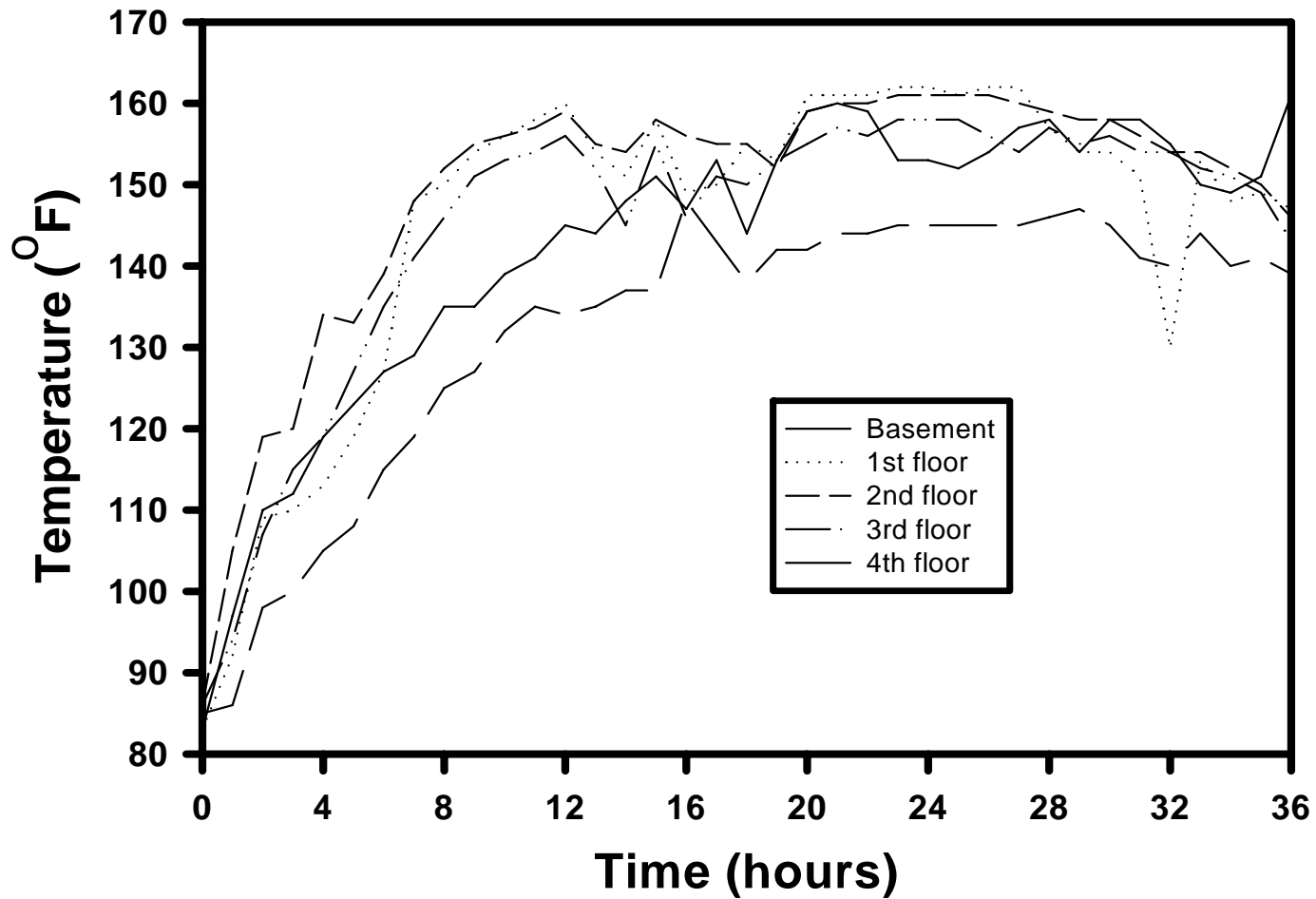
Use portable fans/ducts for hard-to-reach areas



Temperature Measurement is Essential and Critical!



August 4-6, 1999 Heat Treatment of KSU Pilot Feed Mill



Why are temperatures not consistent among floors and within floors?

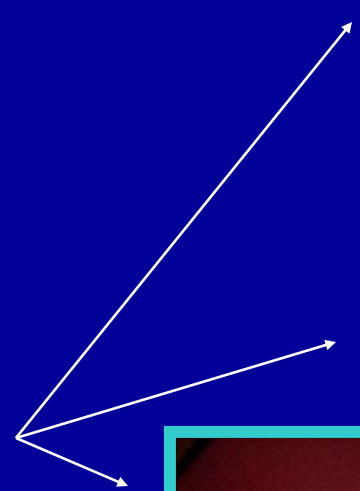
Aug. 4-6, 1999 Gas Heat Treatment Feed mill, KSU

Location	Hours to reach 50°C	Hours above 50°C	Maximum temperature (°C)
Basement	4-4.3	31.7-32	71.7
1 st floor	1.5-3.2	32.8-34.5	63.9
2 nd floor	2.1-2.4	33.6-33.9	70.7
3 rd floor	3.1-3.4	32.6-32.9	70
4 th floor	7.2-8	28-28.8	64.4
Warehouse	1.3-2.3	33.7-34.7	65.6

Heater discharge: 62.8-104.4°C. Outside: 22.2-24.4°C. Mill: 28.3-30.6°C.

Success Depends on.....

- Determining the right heat energy requirements (BTUs)
- Eliminating cool spots through air movement
- Determining effectiveness against insects
- Preventing heat loss through effective sealing



Heat Treatment in Action

[Movie](#)

Zone Treatment

- **Size Matters**
 - Energy costs
 - Prep time
 - Shut down time
 - Risk to damage
- **High Risk Areas**
 - PLC's, computers, high risk equipment
 - See manufacturers specs.

Zoning Down

- Careful insect assessment
- Applied other methods
 - Vacuuming
 - Environmental modification
 - Equipment
 - Structural
- Treatment Applicability

Spot Treatments



6 6:21 PM

Challenges - Spot Treatments



- Tarping is time consuming
- Enough heat?
- Enough circulation
- Insect movement to non heated areas

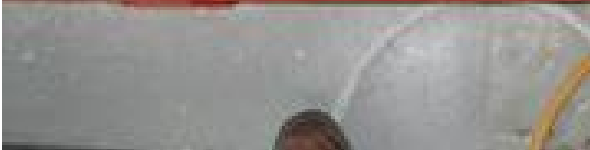


Empty-Bin Treatments



- Confined space
- Limited access
- Bin type & location
- Air movement

Challenges



Challenges



- Duct hot air from bottom to top
- Need fans for high circulation
- Concrete vs Steel

CO₂ for Bulk Storage

- Organic Rice Mill - Southern US
- Large Steel bulk Storage
 - Bins 60' H x 48' D - 48,000 lbs CO₂
 - and 45' H x 36' D - 28,000 lbs CO₂
 - Target of >60% CO₂
 - 5 days exposure and 2 days aeration
 - Some > 10 years old
 - Recirculation system

The Use of N₂ in Grain Storage

Table 1. Mortality of *Tribolium castaneum* subjected to a nitrogen based controlled atmosphere of greater than 98%

Trial	Wheat class	Exposure period (days)	Temp. (°C)	Moist. (%)	Mortality (%)**					
					L1	L2	L3	Control	F1 (test)	F1 (control)
1	CWAD	7	22	12.5	98.3	98.3	Lost	0	a	p
2	CPS	7	16	13.5	3.3	0	1.7	5	p	p
5	CPS	7	15	13.2	100	100	100	1.7	a	p
3	CWRS	14	19	12.8	3.3	3.3	5.0	0	p	p
6	CWRS	14	17	13.0	100	100	100	0	a	p
4	CWRS	21	11	11.8	100	100	95.0	0	a	p

CWAD – Canada Western Amber Durum

CPS – Canada Prairie Spring

CWRS – Canada Western Red Spring

L1 – 10 meters from top of bin

L2 – 20 meters from top

L3 – 29 meters from top

p – present

a - absent

Conclusions

1. Test results demonstrate that *T. castaneum* adults are controlled effectively in a controlled atmosphere. Further test results with design modifications may contribute data on survival of other life stages
2. While not part of this experiment, heated grain (through metabolic processes) subjected to the nitrogen atmosphere stopped heating faster, with less damage and at a lower cost than would be observed with conventional turning practices
3. Integrating N₂ based atmospheres in a grain quality management system can be effective, safe and cost effective.

Low Pressure to Control Postharvest Insects in Durable commodities

Why Low Pressure or Partial Vacuum?

- Controlled atmosphere, reduces all gas concentrations
- Low O_2 level ($< 1\%$) is lethal to insects
- Non-chemical, no residue (MBr alternative)
- Efficacy of low pressure increases with temperature and hold time
- Application in bagged, boxed, packaged commodities (high value commodities like breeder, foundation seed, coffee, cocoa, nuts, dried fruit) via the "Cocoon"

Laboratory Studies with Storage Pests

Time to Kill 99% of Eggs
at Two Temperatures and
Pressures

Indianmeal Moth

	<u>22.5C</u>	<u>37.5C</u>
50 mm	58.0	17.4
100 mm	96.8	23.0

Red Flour Beetle

	<u>22.5C</u>	<u>37.5C</u>
50 mm	69.7	11.7
100 mm	98.1	20.7



Saw-tooth grain beetle – LD99

Pressure (mmHgA)	Life Stage	Temperature, °C			
		15	20	25	30
25	Eggs	123.86 aA (111.14 - 142.18)	122.19 aA (109.16 - 140.50)	46.49 abB (39.27 - 58.09)	19.07 aC (16.54 - 22.93)
	Larvae	31.80 cA (27.20 - 39.68)	31.13 bA (24.08 - 50.55)	6.45 dC (5.47 - 8.18)	5.14 bC (3.62 - 12.96)
	Pupae	42.05 bcA (34.89 - 55.31)	42.29 bAB (29.62 - 101.12)	24.23 bBC (17.49 - 43.79)	12.92 aC (8.97 - 29.33)
	Adults	11.61 dA (10.38 - 13.40)	3.82 dB (3.49 - 4.34)	1.55 *	1.55 *
50	Eggs	144.30 aA (130.63 - 163.34)	136.00 aA (121.87 - 155.75)	50.73 aB (43.10 - 62.75)	21.46 aC (18.59 - 25.85)
	Larvae	49.29 bA (43.55 - 57.78)	38.89 bA (30.51 - 59.00)	11.62 cB (9.87 - 14.54)	3.60 bC (3.10 - 4.44)
	Pupae	50.38 bA (42.57 - 63.74)	47.11 bAB (35.08 - 82.77)	33.44 bB (25.62 - 50.72)	19.21 aC (14.38 - 31.34)
	Adults	37.66 cA (33.42 - 43.86)	9.76 cB (8.49 - 11.78)	6.67 dC (5.36 - 9.50)	1.63 *

Within a row, values with same letter in uppercase are not significantly different

Within a column, values with same letter in lowercase are not significantly different

Infrared Heat Treatment of Grain

Movie

Activities at Hands-on Session

- Heat treatment of a bin
 - Temperature measuring devices
 - Worksheet for participants
- Vacuum treatment
- Bench-top infrared heater
- Questions & Answers