Heat treatment of Mills & Storage structures

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Structural Fumigation

**FUMIGANTS**
- Phosphine - Insect resistance, Corrosion
- Methyl Bromide - Ozone depletion
- Sulfuryl Fluoride - Residues? Dosage?

**CONTACT INSECTICIDES**
- Contact Insecticides - Fogging, Aerosols/ULV - Penetration?
Heat treatment of Mills

>100 Years Ago ...

1913 - Kansas, Mid-West USA, Southern Canada
Heat in mills to control insects

> 100 Years ago.....Manhattan, Kansas

In Kansas the heating of more than twenty mills has absolutely proven that no stage of insect, even in the most inaccessible places, could withstand the heat.....February, 1913
Drivers - Heat Treatment (HT)?

- Consumer Preference
  - Pesticide-free Products
- Eco-Friendly Technology
  - Montreal Protocol
    - US Clean Air Act
- Insect Resistance
  - Higher dosage, Life stages?

Green IPM
Temperature Effects on Insects

Targeted temp. spectrum 120 - 140°F (50-60°C)

Source: P. Fields, AAFC, Canada
Heat treatment Concept

Kills **ALL** Stages of Insect Life Cycle

- Adult
- Pupa
- Larva
- Eggs

120°F Minimum

140°F Maximum
Heat - Advantages

- Safe
- Effective
- Co-friendly

- Non-Chemical
- People-Safe
- Kills all life stages
- No ozone depletion
- No Toxicity or Corrosion issues

Can go inside for inspections DURING the heat treatment

- No evacuation of People
- No Sealing
- Spot Treatments
Efficacy to Control Pests

- MBr – Methyl bromide
- PH₃ - Phosphine
- SF (Profume)
- CO₂ – Carbon dioxide
- O₃ - Ozone

Efficacy – function of temperature – Winter fumigation?

Heat treatments – Throughout the year!
Christmas Heat treatment - December Snowing!

Outside temperature: 26-30°F/ -1 to -3°C
Heat Treatment

High Temperature
[120 - 140°F/(50 - 60°C)]

Gradual

HT Process

Ambient temperature

Low Humidity (≤ 25%)
(Desiccation/Dehydration)

Insect Death by Dehydration (low RH)/desiccation
Heat & Insect Death

➢ High temperature -
  • Death by Dehydration (low RH)/desiccation

➢ Above 50 °C / 120 °F
  • Cell membranes “melt”
  • Enzyme destruction
  • Change in salt balance
  • Protein coagulation
Heat treatment concept: Raising the ambient air temperature of the complete facility, or a part of it, to 50-60°C (122-140°F), and maintaining these temperatures for at least 24 hours.
Process
Positive Pressurization – Forced ambient air
(Patented Process)

- Positive pressure
  - Good air distribution
  - Hot air is pushed into corners, cracks and crevices
- Calculated and controlled infiltration - air changes
- Lower relative humidity

US & Canadian Patents
Re-circulating Inside Air

- Negative pressure
- Poor air circulation
- Uncontrolled infiltration
  - No air changes

Low temperature zones (cold spots)
Real-time Wireless Temperature Monitoring

Untreated Area (Office)

Treated Area

Temperature transmitters

Heater

Receiver
Start of the Heat Treatment

Fig. 1: Real-time Temperature Profile from Sep 16, 2006, 06:35 AM to 09:05 PM

Tx:49 sensor in office on 3rd floor

Temperature (°F)

0 20 40 60 80 100 120 140 160

(50°C) (49°C) (48°C) (47°C) (46°C) (45°C) (44°C) (43°C) (42°C) (41°C) (40°C)

(60°C)

(38°C)

(27°C)

START

12:30 hr

START 24 hour hold-time

Tx:49 sensor in office on 5th floor
End of the Heat Treatment

Fig. 1: Realtime Temperature Profile from Sep 16, 2006, 06:35 AM to 09:05 PM

Tx: 49 sensor in office on 3rd floor

Fig. 2: Realtime Temperature Profile

(60°C)
(49°C)
(38°C)
(27°C)

Tx: 49 sensor in office on 5th floor

Temperature (°F)
Steps in Heat Treatment

Visit & Feasibility

Engineering, Equipment & Estimate

Setup, HT, Document & Review

Equipment mobilization
Important Pre-heat Treatment Checklist

➢ Remove tension from drive belts to avoid stretching
➢ Perform sanitation and remove all food products
➢ Sprinkler heads should withstand 127°C
➢ Protect heat sensitive equipment
Sanitation is the key

Important as heat does not penetrate products well.
Perimeter Spray/Dust
Apply a residual pesticide such as cyfluthrin (Tempo) or diatomaceous earth
Comparison of Heat Tolerant Stages of Four Species ($LT_{99}$ in minutes (95% CL))

<table>
<thead>
<tr>
<th>Species</th>
<th>Stage</th>
<th>46°C/115°F</th>
<th>50°C/122°F</th>
<th>54°C/129°F</th>
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<tbody>
<tr>
<td>Cigarette beetle</td>
<td>Eggs</td>
<td>598.1</td>
<td>165.45</td>
<td>37.87</td>
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<td></td>
<td></td>
<td>(571.21-633.10)</td>
<td>(152.62-182.84)</td>
<td>(35.14-41.56)</td>
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<tr>
<td>Red flour beetle</td>
<td>Young larvae</td>
<td>430.7</td>
<td>432.8</td>
<td>81.9</td>
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<tr>
<td></td>
<td></td>
<td>(364.3-573.6)</td>
<td>(365.3-572.6)</td>
<td>(60.4-207.7)</td>
</tr>
<tr>
<td>Confused flour beetle</td>
<td>Mature larvae</td>
<td>299.46</td>
<td>90.05</td>
<td>55.71</td>
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<tr>
<td></td>
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<td>(281.81-324.88)</td>
<td>(81.80-102.26)</td>
<td>(48.75-67.25)</td>
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<tr>
<td>Indianmeal moth</td>
<td>Mature larvae</td>
<td>69</td>
<td>34</td>
<td>Not tested</td>
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<tr>
<td></td>
<td></td>
<td>(62-80)</td>
<td>(29-43)</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Dr. Subi, KSU, KS*
Red flour beetle

Young larvae are heat tolerant

Source: Dr. Subi, KSU, KS
Confused flour beetle

Old larvae are heat tolerant

Source: Dr. Subi, KSU, KS
<table>
<thead>
<tr>
<th>Insect stage</th>
<th>Sanitation level</th>
<th>Treatment</th>
<th>% Mean (SE) mortality&lt;sup&gt;a&lt;/sup&gt;</th>
<th>F</th>
<th>P</th>
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<tr>
<td>Adults</td>
<td>2 cm</td>
<td>MB</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.90</td>
<td>&lt;0.0001</td>
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<td></td>
<td></td>
<td>SF</td>
<td>100&lt;sup&gt;a&lt;/sup&gt;</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>90.1 (1.2)&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>dusting</td>
<td>SF</td>
<td>100</td>
<td>1.00</td>
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<td></td>
<td></td>
<td>MB</td>
<td>100</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>98.7 (1.3)</td>
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<td></td>
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<tr>
<td>Pupae</td>
<td>2 cm</td>
<td>MB</td>
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<td>2.56</td>
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<td>SF</td>
<td>100</td>
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<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>95.4 (2.9)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>dusting</td>
<td>MB</td>
<td>100</td>
<td>0.60</td>
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<td></td>
<td></td>
<td>SF</td>
<td>98.7 (1.3)</td>
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<td></td>
<td></td>
<td>Heat</td>
<td>97.3 (2.7)</td>
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<tr>
<td>Large larvae</td>
<td>2 cm</td>
<td>MB</td>
<td>99.8 (0.1)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.62</td>
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<td></td>
<td></td>
<td>SF</td>
<td>100 (0.0)&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>96.1 (1.3)&lt;sup&gt;b&lt;/sup&gt;</td>
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<td></td>
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<td></td>
<td></td>
<td>Heat</td>
<td>98.2 (1.3)</td>
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<td>Small larvae</td>
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<td>Heat</td>
<td>93.5 (2.8)&lt;sup&gt;b&lt;/sup&gt;</td>
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<td></td>
<td>Heat</td>
<td>99.4 (0.3)</td>
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<td>92.3 (7.3)</td>
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<td></td>
<td></td>
<td>Heat</td>
<td>99.3 (0.3)</td>
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<tr>
<td></td>
<td>dusting</td>
<td>MB</td>
<td>99.9 (0.1)</td>
<td>1.25</td>
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<tr>
<td></td>
<td></td>
<td>SF</td>
<td>88.7 (10.0)</td>
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<tr>
<td></td>
<td></td>
<td>Heat</td>
<td>99.8 (0.1)</td>
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</tr>
</tbody>
</table>

K-State Study (2009-2010)

n = 3/trt

Trt time=24 h for all
Exponential Growth of Insect Populations

One month - 20 times
Two months - 500 times
Ten thousand times - 3 months

Number of insects vs. Month for S. oryzae 14% mc at 18°C, 25°C, and 29°C.
THERMAL REMEDIATION
Industrial Applications

• Food Processing
• Rice Mills
• Flour Mills
• Pet Food
• Corn Mills
• Cereal Processing
• Bakeries
• Warehouses

• Baby Food Plants
• Wood Packaging
• Tobacco Companies

Organic processing plants/storages
Entire structure or spot treatment
Heat Treatment of Bins & Silos
Bins & Silos

► Pre-loading or Pre-harvest HT
  • On-farm bins
  • Elevators storages
  • Processing facilities
  • Organic processing plants

► Bin/Silo types
  • Concrete
  • Metal
    • GI bins
    • Tanks
HT of bins and silos

Hopper bottom

Flat bottom
Bin/Silo Heat treatment

Empty Metal Silo - India
Advantages of HT of Bins/Silos

- **S E E**
- Shorter treatment times (4 to 12 hours)
- Bins/Silos in facilities
  - Treated in rotation without shut-down
- No retrofitting – existing transition, bin-entry
- On farm or warehouses – no extensive sealing or evacuation
Conclusions

- Heat kills all life stages of insects
- Good method to locate insect problems in industrial plants
- Repeat customers = efficacy of heat
- Viable alternative to methyl bromide
- Economies of scale - will make it more affordable
On Site Images

Heater Placement on multiple floors

Heater Placement under rolling shutter
Heater Placement & Layout

Heater Partially inside Packaging Plant

Duct & Fan Layout - Packaging
Wireless Temperature Sensors
Placed Inside Sensitive Equipment

Basement, Sensitive Equipment
Partial/Spot heat treatment in a Warehouse/Plant

Packaging Area in warehouse

Spot Treatment in Cookie Packaging Plant
Sprinkler heads and opening the machines
Temperature Profile, Beetles, & Rats!!!!
Concrete Bins, Basement and Head house
High temperature duct through the ‘well’ of Stairwell to six floors of the mill
Packaging Hall
Heat Treatment: Scientific Process

It’s more of an Art – **HOW** you apply it