HEAT TREATMENTS

An Effective & Viable Alternative To Chemical Fumigation For Stored Product Insects

Flour Mills, Warehouses & 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?
First Use of Heat

256 Years Ago . . .

In 1762 – France: 69°C/ 156°F for 3 d, moth
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

...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, and several flour mills in Ohio, Illinois, Indiana, Iowa, Nebraska, southern Canada, and elsewhere, have corroborated the practicability and the efficiency of heat as a means of controlling mill insects.
Drivers - Heat Treatment (HT)?

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

Green IPM
Heat - Advantages

SAFE • EFFECTIVE • CO-FRIENDLY

- Non Chemical
- People-Safe
- Kills all life stages
- No ozone depletion
- No Toxicity or
- Corrosion issues
- No evacuation of People • No Sealing • Spot Treatments
Temperature Effects on Insects

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

Temperature (°C)

Temperature (°F)

-30 -20 -10 0 10 20 30 40 50 60 70

-20 0 20 40 60 80 100 120 140

DEATH IN MINUTES

DEATH IN A DAY

SLOWER GROWTH

MAXIMUM GROWTH

SLOWER GROWTH

DEATH IN WEEKS OR MONTHS

DEATH IN DAYS, OR MONTHS IF ACCLIMATED

DEATH IN MINUTES

Source: P. Fields, AAFC, Canada
Efficacy to Control Pests

- MBr – Methyl bromide
- PH$_3$ - Phosphine
- SF (Profume)
- CO$_2$ – Carbon dioxide
- O$_3$ - Ozone

Efficacy – function of temperature
Heat & Insect Death

- **High temperature**
  - Death by Dehydration (low RH)/desiccation
- **Above 50 °C / 122 °F**
  - Cell membranes “melt”
  - Enzyme destruction
  - Change in salt balance
  - Protein coagulation
Heat Treatment

Insects – lethal threshold temperatures

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

HT Process
Gradual
Ambient temperature

Low Humidity (≤ 25%)
(Desiccation/Dehydration)
**Heat treatment concept:** Raising the ambient air temperature of the complete facility, or a part of it, to 122-140°F (50-60°C), and maintaining these temperatures for at least 24 hours or less depending on application.
Process
Positive Pressurization – Forced ambient air
(Patented Process)

**US & Canadian Patents**

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

- Monitor Temperatures throughout heated area
- Manage airflow for Uniform Temperature Profile
- Real-time Wireless Temperature Monitoring System
  - Potential for Damage
  - Insect Survival
  - Real-time adjustment
  - Documentation for QC
  - Worker Safety & Savings
Start of the Heat Treatment

Fig. 1: Real-time Temperature Profile
End of the Heat Treatment

Fig. 2: Real-time Temperature Profile

Temperature (°F)

(60°C)
(49°C)
(38°C)
(27°C)

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

Temperature (°F)

(27°C)
(38°C)
(49°C)
(60°C)
Heat Treatment Checklist

- **Before**: cleaning, drive belts, product removal, sprinkler heads, sensitive eqpmnt etc.
- **During**: Intrusive, temperature points/frequency, fans and/or duct movement for airflow and heat distribution
- **After**: cool down, insect bioassays, inspection etc.
Heat Damage

Make a list of heat susceptible equipment
Sanitation is the key

Important as heat does not penetrate products well.
Apply a residual pesticide such as cyfluthrin (Tempo) or diatomaceous earth
Exponential Growth of Insect Populations
S. oryzae 14% mc

Month
0 1 2 3
Number of Insects
0
1e+5
2e+5
3e+5
4e+5
5e+5
6e+5
7e+5
8e+5
9e+5
1e+6
1e+6
18 °C
25 °C
29 °C

100
500
150,000
1,000,000

0 1 2 3
Month
For successful Heat Treatment

- Engineering Design for structure - building parameters to determine heat energy (BTUs) - Site Visit
- Airflow Management - Cold & Hot Spots
- Physical Exclusion & Sanitation
- Pre & Post Heat treatment Insect counts for population rebounds
- Learning Curve
Heat versus Fumigants
<table>
<thead>
<tr>
<th>Insect stage</th>
<th>Sanitation level</th>
<th>Treatment</th>
<th>% Mean (SE) mortality</th>
<th>$F$</th>
<th>$P$</th>
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<td>Adults</td>
<td>2 cm</td>
<td>MB</td>
<td>100a</td>
<td>69.90</td>
<td>&lt;0.0001</td>
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<td>SF</td>
<td>100a</td>
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<td></td>
<td></td>
<td>Heat</td>
<td>90.1 (1.2)b</td>
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<td>SF</td>
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<td>Heat</td>
<td>98.7 (1.3)</td>
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<td>Adult pupae</td>
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<td>Heat</td>
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<td></td>
<td>Heat</td>
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<td>Large larvae</td>
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<td>Heat</td>
<td>99.8 (0.1)</td>
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</table>

K-State Study (2009-2010)

$n = 3/\text{trt}$

Trt time=24 h for all
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

Proactive - Preventative
&
Reactive - Response
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
Advantages of HT of Bins/Silos

- 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
Wireless Temperature Sensors Placed Inside Sensitive Equipment
Detecting hidden infestations

Wireless temp sensor

Overhead electrical junction box

10,000s of adults, larvae, pupae!!
Partial/Spot heat treatment of Mill extension in a warehouse Philippines - March 2018

A temporary Plastic Sheet OR Fumigation cover - No Sealing
Partial/Spot heat treatment of Packaging Area in a warehouse (Canada)
Sprinkler heads and opening the machines
Temperature Profile, Beetles, & Rats!!!!
Christmas Heat treatment
December – Snowing!

Outside temperature: 26-30°F / -1 to -3°C
Flour Mill, Celaya, Mexico

High temperature duct through the ‘well’ of Stairwell to six floors of the mill
Flour Mill, Philippines

Dead beetles, cockroaches
Concrete floor
Concrete floor & wall

Hole in the duct
Heat Treatment: Patented Scientific Process

It’s more of an Art – **HOW** you apply it
JUST HEAT IT.

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