Transportable hermetic storage and vacuum equipment for disinfestation of durable commodities

Agricultural Research Organization, The Volcani Center, Israel

Nationwide exterminating, (Israel) Ltd.

Simcha Finkelman, Shlomo Navarro, Miriam Rindner and Refael Dias

e-mail: <simcha@pest.co.il>
Aims of the developed technologies and consumer demands

- Environmentally friendly
- Efficient
- Affordable price
- Simple to handle
- Free from toxic chemicals
Core concept of the technology

The presented technologies are based on flexible PVC liners that *enclose and seal* the treated commodity providing an atmospherically controllable treatment chamber.

The *manipulation* of the modified atmosphere treatment is determined by the specific requirements of the *commodities* and the manufacturing processes.
The range of environmentally friendly technologies that can be implemented as alternatives to methyl bromide

- **Modified atmospheres:**
  - Low pressures
  - Enriched CO₂ atmosphere
  - Enriched N₂ atmosphere
  - Hermetic storage (bio-generated atmospheres)

- **Heat**

- **Environmentally friendly fumigants**

- **Integration of treatments**
Two technologies already adopted by the industry

- **Low pressure technology** (Vacuum)
  - Quarantine treatments for commodities that are packaged in bags.
  - Insect control treatments upon demand.
  - Quality assurance during storage.

- **Hermetic technology** (bio-generated atmospheres)
  - Quarantine treatments for commodities with high respiration rates such as: geophytes, onions, potatoes.
  - Insect control treatments of stored commodities such as grain.
Low pressure (Vacuum) technology

In order to simplify this technology for the end-user in Israel the following treatment protocol was chosen:

- **Commodity conditions:**
  - Commodity temperature at about 30°C
  - Commodity relative humidity at about 55%

- **Treatment conditions**
  - Pressure of the treatment at about 50 mm Hg
  - Exposure time depending on the insect species
A complete vacuum set-up

PVC enclosure

Pump

50 mm Hg

Zipper

Quick release connection

one-way vacuum line valve

Lisbon

29/9/2004
**V-HF** *(vacuum hermetic fumigation) treatment chamber*

- Actual pressure measured directly in the chamber
- Front opening
- Zipper
- Pump
- Loading on pallets
The pump and the control panel of the vacuum system

- **6 mm diam. tube for cube pressure measurements**
- **Vacuum hose connected to the cube**
- **Transducer for pressure monitoring**
- **Transmitting unit**
- **Filters**
- **Control panel of the pump**
The effect of 50 mm Hg on egg mortality at 55% r. h. and 30°C

<table>
<thead>
<tr>
<th>Test insects</th>
<th>LT$_{99}$ values (hours to obtain 99% mortality)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Trogoderma granarium</em></td>
<td>46 h</td>
</tr>
<tr>
<td><em>Lasioderma serricorne</em></td>
<td>91 h</td>
</tr>
<tr>
<td><em>Oryzaephilus surinamensis</em></td>
<td>32 h</td>
</tr>
<tr>
<td><em>Tribolium castaneum</em></td>
<td>22 h</td>
</tr>
<tr>
<td><em>Ephestia cautella</em></td>
<td>45 h</td>
</tr>
<tr>
<td><em>Plodia interpunctella</em></td>
<td>49 h</td>
</tr>
</tbody>
</table>
### Semi-commercial field tests that produced 100% mortality of insects

<table>
<thead>
<tr>
<th>Treated Commodity</th>
<th>Infestation found in the treated commodity</th>
<th>Test insects used in the trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oat</td>
<td><em>T. castaneum</em>, <em>O. surinamensis</em></td>
<td><em>E. cautella</em></td>
</tr>
<tr>
<td>Corn chips</td>
<td><em>E. cautella</em></td>
<td><em>T. castaneum</em>, <em>E. cautella</em>,</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>O. surinamensis</em>,</td>
</tr>
<tr>
<td>Cocoa beans</td>
<td></td>
<td><em>E. cautella</em>, <em>O. surinamensis</em>,<em>T. castaneum</em>,</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>P. interpunctella</em></td>
</tr>
<tr>
<td>Wheat</td>
<td><em>S. oryzae</em>, <em>O. surinamensis</em></td>
<td><em>O. surinamensis</em></td>
</tr>
<tr>
<td></td>
<td><em>T. castaneum</em></td>
<td></td>
</tr>
<tr>
<td>Wheat flour</td>
<td><em>R. dominica</em> <em>O. surinamensis</em></td>
<td><em>T. castaneum</em>, <em>O. surinamensis</em>, <em>E. cautella</em></td>
</tr>
<tr>
<td></td>
<td><em>T. castaneum</em></td>
<td></td>
</tr>
<tr>
<td>Semolina</td>
<td></td>
<td><em>T. castaneum</em>, <em>O. surinamensis</em>, <em>E. cautella</em></td>
</tr>
</tbody>
</table>
### Semi-commercial field tests that produced 100% mortality of insects (continued)

<table>
<thead>
<tr>
<th>Treated Commodity</th>
<th>Infestation found in the treated commodity</th>
<th>Test insects used in the trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds</td>
<td></td>
<td><em>O. surinamensis</em>, <em>L. serricorne</em>, <em>E. cautella</em></td>
</tr>
<tr>
<td>Garden peas</td>
<td></td>
<td><em>C. chinensis</em>, <em>S. oryzae</em>, <em>T. castaneum</em></td>
</tr>
<tr>
<td>Chick peas</td>
<td><em>S. oryzae</em>, <em>C. chinensis</em>, <em>T. castaneum</em>, <em>R. dominica</em></td>
<td><em>C. chinensis</em>, <em>S. oryzae</em>, <em>T. castaneum</em></td>
</tr>
<tr>
<td>Sun flower sees</td>
<td></td>
<td><em>T. castaneum</em>, <em>L. serricorne</em>, <em>E. cautella</em></td>
</tr>
<tr>
<td>Semolina</td>
<td></td>
<td><em>T. castaneum</em>, <em>O. surinamensis</em>, <em>E. cautella</em></td>
</tr>
<tr>
<td>Rice</td>
<td><em>T. castaneum</em>, <em>S. oryzae</em>, <em>O. surinamensis</em></td>
<td><em>O. surinamensis</em>, <em>E. cautella</em>, <em>S. oryzae</em></td>
</tr>
</tbody>
</table>
Quality assurance of soybeans imported from Canada adopted by Israeli manufacturer

Cost analysis:

Installation costs (20 tons cube + pump + ancillary) = €6580
Optional handling & operational costs (per 20 tons treatment) = €18
Treatment cost based on 10 year amortization = €1.2
Hermetic technology
(bio-generated atmospheres)

This technology was developed to enable bulb growers to replace methyl bromide quarantine fumigation with a non chemical treatment:

- **Commodity conditions:**
  - Commodity temperature is 30°C

- **Treatment conditions**
  - Reduction of oxygen concentration to below 1%
  - Exposure time of 72 hours (specifically against the large narcissus fly)
A fan circulating hot air within the chamber to obtain 30°C
bio-generated atmospheres
Reducing $O_2$ concentration by bulbs respiration

Adhering the liner to the crates by removing excess air with vacuum cleaner

When oxygen level drops to below 1% hermetic seal is held for additional 3 days
Quarantine treatment of narcissus bulbs as alternative to methyl bromide for Israeli growers

Bulbs held in transport crates on pallets ready for shipment

Loading pallets into treatment chamber and installation of heat circulation equipment

Exposure for treatment time duration

Shipment

Cost analysis:

MB - Total annual costs for MB fumigation were: €6240
(1070 tons at €5.8/ton)

Hermetic - Price of each cocoon is about €2200 (6 units €13200)
Handling & operation is carried out by growers

Growers recuperate expenses in about two seasons of use with no future expense
Acknowledgement

This research was a collaborative project with Eitan Amichai and GrainPro supported by a grant from the United States-Israel Science and Technology Foundation (USISTF), ARO Project No. 417-0384-02
Information on the application of these technologies can be found at:

GrainPro, Inc., 200 Baker Avenue, Suite 309, Concord, MA 01742 USA
sales@grainpro.com • www.grainpro.com

or

Eitan Amichai, Nationwide Exterminators Ltd., Israel
www.pest.co.il
### Units used to express atmospheric pressure and their equivalent partial pressure of oxygen expressed in mm Hg and in percentage

<table>
<thead>
<tr>
<th>mm Hg (torr)</th>
<th>atmosphere</th>
<th>kg/cm²</th>
<th>inches Hg</th>
<th>kPa</th>
<th>mbar</th>
<th>mm Hg Oxygen</th>
<th>% Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>760</td>
<td>1.00</td>
<td>1.03</td>
<td>29.92</td>
<td>101,325</td>
<td>1,013</td>
<td>159</td>
<td>20.9</td>
</tr>
<tr>
<td>600</td>
<td>0.79</td>
<td>0.82</td>
<td>23.62</td>
<td>79,993</td>
<td>800</td>
<td>125</td>
<td>16.5</td>
</tr>
<tr>
<td>500</td>
<td>0.66</td>
<td>0.68</td>
<td>19.68</td>
<td>66,661</td>
<td>667</td>
<td>105</td>
<td>13.8</td>
</tr>
<tr>
<td>400</td>
<td>0.53</td>
<td>0.54</td>
<td>15.75</td>
<td>53,329</td>
<td>533</td>
<td>84</td>
<td>11.0</td>
</tr>
<tr>
<td>300</td>
<td>0.39</td>
<td>0.41</td>
<td>11.81</td>
<td>39,997</td>
<td>400</td>
<td>63</td>
<td>8.3</td>
</tr>
<tr>
<td>200</td>
<td>0.26</td>
<td>0.27</td>
<td>7.87</td>
<td>26,664</td>
<td>267</td>
<td>42</td>
<td>5.5</td>
</tr>
<tr>
<td>100</td>
<td>0.13</td>
<td>0.14</td>
<td>3.94</td>
<td>13,332</td>
<td>133</td>
<td>21</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>50</strong></td>
<td><strong>0.07</strong></td>
<td><strong>0.07</strong></td>
<td><strong>1.97</strong></td>
<td><strong>6,666</strong></td>
<td><strong>67</strong></td>
<td><strong>11</strong></td>
<td><strong>1.4</strong></td>
</tr>
<tr>
<td><strong>0</strong></td>
<td><strong>0.00</strong></td>
<td><strong>0.00</strong></td>
<td><strong>0.0</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
<td><strong>0.0</strong></td>
</tr>
</tbody>
</table>