Sulfuryl Fluoride
ProFume* Gas
Fumigant

Technical Update

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ProFume* Development

- Dow AgroSciences investigated sulfuryl fluoride as a MeBr alternative for postharvest insect control.

- Initial research focused on flour mills, food processing facilities, warehouses, and stored grains.

- Cooperative research since 1995 with researchers, food scientists, food commodity groups, industry consultants, and fumigators in Australia, Europe, Japan, and the United States.
More Similarities Between ProFume & MeBr Than Differences

Both are excellent fumigants that:
- have wide pest control spectrums
- are non-flammable and odorless
- have similar vapor density and molecular weights
- are non-corrosive in vapor phase
- utilize CT dosage relationship

Dosage = Concentration X Time
## Key Differences: Fumigant Properties

<table>
<thead>
<tr>
<th>Factor</th>
<th>SF</th>
<th>MeBr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone Depleter</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Penetration</td>
<td>Rapid</td>
<td>Slow</td>
</tr>
<tr>
<td>Sorption</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Desorption</td>
<td>Rapid</td>
<td>Slow</td>
</tr>
<tr>
<td>Aeration</td>
<td>Rapid</td>
<td>Slow</td>
</tr>
<tr>
<td>Odor Potential</td>
<td>None</td>
<td>Sulfurous</td>
</tr>
</tbody>
</table>
### Key Differences: Packaging & Use

<table>
<thead>
<tr>
<th>Factor</th>
<th>SF</th>
<th>MeBr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Weight (net)</td>
<td>125 lb</td>
<td>45-200 lb</td>
</tr>
<tr>
<td>Pressure @ 86°F</td>
<td>300 psi</td>
<td>25 psi</td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td>No*</td>
<td>Depends</td>
</tr>
<tr>
<td>Volume Control</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Hose Length/Dia</td>
<td>Outside</td>
<td>Depends</td>
</tr>
<tr>
<td>Shooting</td>
<td>Outside</td>
<td></td>
</tr>
</tbody>
</table>

- Introduction fans act to improve fumigant distribution and as an internal heat exchanger
Pests Controlled With ProFume

- Wide spectrum of insect and rodent (rats, mice) pests in postharvest cereal grain, dried fruit, and tree nuts.
- All life stages.
- Partial list of key pests includes:
  - Moths (IMM, MFM, CM, NOW, & AM)
  - Weevils (Granary, Rice, & Maize Weevil)
  - Beetles (RFB, CFB, STGB, LGB, & WHB)
ProFume Will Be Labeled For Use On:

Cereal Grains
- Wheat
- Rice
- Corn
- Sorghum
- Barley
- Oats

Dried Fruits
- Raisins
- Prunes
- Figs
- Apples
- Apricots
- Bananas
- Dates
- Other dried fruits

Tree Nuts
- Walnuts
- Almonds
- Hazelnuts
- Pecans
- Other Tree Nuts

- Other commodities are being investigated.
ProFume Development 1997 - 2003

39 Fumigations at 25 Sites:

- California: 11 mill fumes at 5 mill sites; 5 chamber fumes at 2 mill sites
- U.S. Midwest: 12 mill fumes at 8 mill sites
- Germany: 4 mill fumes at 3 mill sites
- England: 2 mill fume at 2 mill site
- Italy: 1 mill fume at 1 mill site
- France: 1 mill fume at 1 mill site
- Switzerland: 3 mill fume at 3 mill site (Received Registration)
Sulfuryl Fluoride Effects: Mills and Equipment

- Non-Flammable gas
- Not corrosive in gaseous phase
- Stable to 400°C, an inorganic gas
- Safe for use on sensitive electronic equipment and mechanical systems
- No complaints from fumigated facilities!
- Sulfuryl fluoride has been used in all sorts of structures for over 40 years!
Precision Fumigation: “Optimizing fumigant use to maximize efficiency and minimize risk.”
Pest Efficacy

- Effective on all key stored product insect and rodent pests
- Dosage is species dependent
- ProFume* can control all life stages of insects including eggs and diapausing stages
- Postembryonic stages controlled with relatively low dosages
- Egg stage requires higher dosages
Temperature Factor

- Key factor for successful fumigation
- Insects cold-blooded, so increasing TEMP increases metabolism
- Increasing insect metabolism greatly improves efficacy of ProFume*
- Increasing TEMP decreases exposure time and gas needed.

*Increasing TEMP from 75° to 85° F, significantly decreases gas needed
Temperature Factor

Methods for increasing temperature:
- Permanent / Built-in
  - hot water, steam, electric, fossil fuels, solar
- Temporary / Leased
  - gas, electric, other
- Time of Day
- Seasonal
Exposure Time Factor (T)

- Key component of $C \times T = \text{Dosage}$
- Increased time = Decrease gas needed
- Decreased time = Increase gas needed
- If structure has good gas confinement, increasing fumigation time is most cost effective factor available
- Plan to maximize exposure time to minimize gas needed.

Doubling exposure time can decrease gas needed by up to 50%
## Optimizing Time and HLT Factors

Amount Of Fumigant Needed With Various HLT and Exposures

<table>
<thead>
<tr>
<th>Exposure Time</th>
<th>HLT 5</th>
<th>HLT 10</th>
<th>HLT 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 hrs</td>
<td>1.13X</td>
<td>0.69X</td>
<td>0.56X</td>
</tr>
<tr>
<td>24 hrs</td>
<td>1.00X</td>
<td>0.55X</td>
<td>0.44X</td>
</tr>
<tr>
<td>32 hrs</td>
<td>0.94X</td>
<td>0.47X</td>
<td>0.34X</td>
</tr>
<tr>
<td>48 hrs</td>
<td>0.90X</td>
<td>0.40X</td>
<td>0.27X</td>
</tr>
</tbody>
</table>

Doubling exposure time with good HLT decreased gas cost significantly.
Dosage Determined with ProFume* Fumiguide* Calculator

- A MS-Windows based PC program
- “Precision Fumigation” dosage tool
  - based on pest species, life stage, temp., exposure time, volume, and load factor
  - also gives gas introduction instructions
- Allows “what if” scenarios to help fumigators and customers
- Records fumigation data
- Prints reports
* TM Dow AgroSciences LLC
ProFume* Stewardship
Commitment To Training & Stewardship

- Key to Long Term Success
- Required Fumigator Participation
- Basic to Dow AgroSciences Fumigant Offering:
  - Extensive Training Program
  - Continuous Improvement in Methods and Materials
  - Utilizing Precision Fumigation Techniques
  - Enhanced Support to Industry
ProFume*
Timelines
ProFume* Sites and Commodities

- Sites
  - Flour Mills, DF&TN plants, Grain Storage
  - Food Processing Plants

- Commodities
  - Cereal Grains: Wheat, Rice, Corn, Sorghum, Barley, Oats and other
  - Dried Fruits and Tree Nuts
  - Processed Foods (complex products)
  - Pet Food
Anticipated ProFume* Registration and Use Timelines

- 2003 - US Section 3 Label Cereal Grains, and Dried Fruit & Tree Nuts
- 2003 - Limited Launch In Cereal & DF&TN markets
- 2004 - US Food Processing Registration
- 2004 - European Approval for Mills and Dried Fruit/Tree Nuts
ProFume* Summary

✓ ProFume is a Viable Fumigant for Mill, Food Processing and Stored Grain Fumigation
✓ No Equipment Effects
✓ No Quality Effects at Label Proposed Dosages
✓ Mill Downtime Same as Now
✓ Fumiguide & Other Tools for *Precision Fumigation*
✓ Precision Fumigation Provides Flexibility to Fit Fumigation to Miller/Fumigator Needs and Budget