Improving Fumigation with Closed Loop Systems

Carol Jones
Oklahoma State University
CLF Mission:

- Seal bins
  - contain as much fumigant as possible
- Circulate fumigant through grain bulk
  - improved distribution
- Hold required concentration
  - specified duration
  - 200 ppm for 100 hours
Review
Phosphine Dosage

- **aluminum phosphide**
  - 1 tablet = 1.0 gram of phosphine gas
  - 1 pellet = 0.2 grams of phosphine gas
  - 1 tablet = 5 pellets
  - 1 case (pellets or tablets) = 7,000 grams of phosphine
  - BUT…check your label…

*Different vendors may package differently*
Review
Phosphine Release Rates

Conditions:
75-85°F and 11-12% moisture content
- Complete release:
  ■ tablets 70-90 hours
  ■ pellets 36-48 hours
- Gas concentration depends upon:
  - dose,
  - temperature,
  - grain moisture,
  - time,
  - absorption
Beetle have four life stages:
- Egg, larva, pupa, adult

Larvae and adults are active stages...
- “breathing” and mobile
- easier to kill

Eggs and pupae are immobile...
- not “breathing” much
- difficult to kill
Review
Phosphine the Insecticide

Sufficient dosage and time required to effectively kill

- **Target dosage:**
  - 200 ppm of phosphine over ...
  - 100 hours to kill all life stages.

Gas loss from a structure depends on:
- weather
- atmospheric conditions
- and leaks in the structure
CLF in flat storage
Flat Warehouse

- Capacity of 3,300,000 bushels
- Closed Loop Fumigation
Fumigation in 2000 (non-CLF)

- 42 cases of pellets
- 42 cases of PH$_3$ = 1,225 ppm for 3.3 million bushels

(Phosphine readings taken from fan outlets)
Fumigation in 2000 (non-CLF)

2000 Fumigation Data

- PPM of Ph$_3$
- Hours after Ph$_3$ Release

Graph showing the concentration of Ph$_3$ over time for different fans and the tunnel.
Fumigation in 2002 (with CLF)

- Dosage was 42 cases of tablets
- Extensive sealing was done in advance (68 man-hours)
  - Top vents and end louvers with tape, glue, 6 mil plastic sheeting;
  - cross belt tunnel and top side entrance with plastic sheeting, glue, sandbags, and lumber;
  - tunnel fans, entrances, and plates with plastic, glue, and tape;
  - fans removed and all holes (man- and rodent-made) sealed with glue, tape, sheeting, and spray foam
Fumigation in 2002 (with CLF)

- Lines were inserted into the headspace and aeration ducts to monitor gas levels.
- Last reading taken 4 hours after roof vents opened.
Fumigation in 2002 (with CLF)

2002 Fumigation Data

- O. space
- SE fan
- SM fan
- SW fan
- NW fan
- NE fan

PPM of Ph₃

Hours after Ph₃ Release

5, 7, 10, 17, 21, 25, 29, 33, 43, 47, 51, 55, 67, 71, 101
Comparison:
2000 (non-CLF) and 2002 (CLF)

Average PPM After Ph₃ Release

- 2000
- 2002

PPM of Ph₃

Hours after Ph₃ Release

- adults dead
- larvae & pupae die
- all life stages dead
What happened?

- **2000 (non-CLF)**
  - Pellets released gas quickly, but levels fell quickly
  - Gas escaped from inadequate sealing
  - Gas levels not high enough for long enough time to kill all life stages

- **2002 (CLF)**
  - Tablets released gas slower, keeping levels higher, longer
  - Thorough sealing kept gas at high levels for >100 hours
CLF in steel bins
Sealing pit vent
Fan connections to bins
CLF plumbing
New CLF installation: Concrete Silos
Bin diagram
Sealing inner connecting vents:

“I didn’t realize how much air was blowing through here!!!” – Mark F., Manager
Sealing top outer vent
Sealing top outer vent
Fan assembly
PVC return to distributor
Distributor connected to bins
Bin plumbing
Bin plumbing
Bin plumbing
Manhole cover at bin bottom with small distributor and valve
Manhole cover on top with strap to hold monitoring equip.
Sealing for fumigation
Dosage:

- Manager’s standard practice:
  - Dose 475 pellets/1000 ft$^3$
- Dosed CLF side and non-CLF side the same
- Monitor gas levels at 3 locations in each bin for 100 hours
Results: CLF versus Conventional Fumigation

[Graph showing CLF versus Conventional Fumigation with ppm on the y-axis and Hour from Treatment on the x-axis. The graph compares CLF and CONVENTIONAL treatments, with CLF surpassing CONVENTIONAL at certain points, indicating higher effectiveness.]
Cost Analysis of Closed-loop Fumigation

The Economics of IPM in Stored Grain

Information by Dr. Brian D. Adam, Ag Econ
Oklahoma State University
## Cost Comparison of Traditional and Closed-loop Fumigation

<table>
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<th>Traditional</th>
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<td>Turning Costs (shrink)</td>
<td>Installation costs</td>
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<tr>
<td>More fumigant</td>
<td>Less fumigant</td>
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<tr>
<td>More labor per fumigation</td>
<td>Less labor</td>
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Summary:

- Installed CLF system treating 6 bins at once
- Treated CLF and Conventional bins with “manager’s standard” dosage
- CLF bins held 10X required concentration
- Conventional bins never reached required concentration
Cost of Fumigation w/ turning vs. Closed-loop Fumigation ($4 wheat)

- Liability insurance
- Training
- Equip. cost (amortized)
- Turning (shrink)
- Electricity
- Fumigant
- Labor

Cents/BU

Fumigation (with turning) vs. Fumigation-Closed Loop
Cost of Fumigation w/ turning vs. Closed-loop Fumigation ($8 wheat)

- Cents/bu

- Liability insurance
- Training
- Equip. cost (amortized)
- Turning (shrink)
- Electricity
- Fumigant
- Labor

Fumigation (with turning) vs. Fumigation- Closed Loop
Advantage CLF

- Higher turning (shrink), fumigant, and labor cost for traditional fumigation outweigh installation cost of closed-loop system.

- The difference is greater the higher the price of wheat, because of shrink.
Take-Home Message:

- CLF saves fumigant
- CLF provides better distribution
- CLF saves $$$
Questions?
PVC connection to aeration
PVC distributor