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# Circulation Fumigation with Phosphine in a Large Warehouse

Zhou Zhongjie and Wen Shengshan

**Abstract**: Good insecticidal results were achieved with a low dose of phosphine in re – circulatory fumigation in a large warehouse.

**Key words**: large warehouse, phosphine, re – circulatory fumigation

## Introduction

Since 1998, the state has invested in the construction of a number of storages in the central grain reserves, where the most common type is a large warehouse. Compared with the general silo, with high grain lines, the characteristics of a large capacity warehouses make fumigation difficult: phosphine penetration is limited, it is not uniformly distributed and incomplete control may cause pest resistance. In light of this situation, we experimented with a low-dose re-circulatory phosphine fumigation in a large warehouse.

## 1 Material and Methods

### 1.1 Test Warehouse

The chosen warehouses were the new large ones: No. 18, 21, and 22, built in the year 2000. With their 48m length, 24m span and grain line 6m, 12000 $m^3$ volume warehouses, warehouse capacity of 5,000 tons; the layout is a group of four with unilateral ventilation. It is made waterproof (with Storage Mainland Ping and permanent Ping).

### 1.2 Condition of Tested Grain

No. 18, 21, 22 warehouses were loaded with the new maize from local farmlands in July 2002. Food and water impurities and other indicators were in line with the state average standards. Specific conditions are shown in Table 1.

### 1.3 Fumigation Operation and the Use of Equipment

1.3.1 Fumigation equipment

**Table 1. Basic food situation**

| Bin NO. | variety | quantity | moisture % | impurity % | geimination % | pest condition(T) variety | density (No./Kg) |
|---|---|---|---|---|---|---|---|
| No. 18 | maize | 5006 | 12.4 | 0.8 | 84.4 | maize weevil | 3 |
| No. 21 | maize | 5006 | 12.7 | 0.5 | 86.5 | maize weevil | 3 |
| No. 22 | maize | 5002 | 12.5 | 0.6 | 85.9 | maize weevil | 2 |

1.3.2 Fumigation operation

*Equipment Connection*: Generator in accordance with the regulations, carbon dioxide intake and carbon dioxide cylinders (connecting five cylinder), and carbon dioxide mixed phosphine, circulation and circulation of inlet and good connections. The circulation fan is connected to power, and its output measured with a wire anemometer measurement. The circulation is regulated taking the wind speed into account. Use soapy water or cleaning agent in the pipeline connecting the smear to check for air bubbles; if they appear, take timely mending leakage measures, such as: a plastic glass or tape.

1.3.3 Confined fumigation

While the 22nd warehouse being closed for16 days, the 18th, the 21st Wharf were closed 22 days after the casual air ventilation, and use of phosphine. Alarm detection warehouses measured concentrations of phosphine. When the concentration of phosphine is below 0.2 mL/$m^3$ (ppm), the staff is allowed to carry out inspection.

*Qinhuangdao Depot Directly Under Central Grain Reserves Economic Developing – area No.* 4 *Beijiing East road, Qinhuangdao, Hebei*, 066206, *P. R. China*

### 1.4 Dosing and Gas Production

In a warehouse of 12 000$m^3$ volume and 0.3 g/$m^3$ administration, aim at 200 mL/$m^3$ concentration (ppm); the first dose is 15 kg. The phosphine gas generator quickly produces phosphine and the release of phosphine in carbon dioxide is used.

### 1.5 Measuring points and position of, insect cages

1.5.1 Gas measurement points

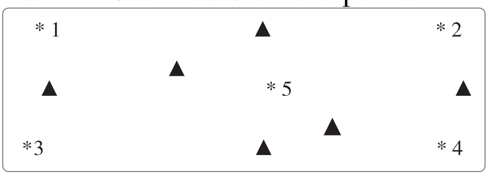


**Fig. 1 Layout of concentration measuring points and pest cages( * measurement point, ▲testing pest cage)**

As shown in Figure 1, five probes for phosphine concentration were deployed in the center of the warehouse at 1.40, and 80 cm depths. They stay in place and each has a plastic hose which leads to the warehouse.

1.5.2 Test insect cage layout

Pest species were taken directly from the warehouses, and also a laboratory culture. See Figure 1 for embedded location, at 30 cm under the grain surface.

1.5.3 Concentration Measurement

In the first application test for leakage with a phosphine Alarm Detection in the pipeline and warehouse doors and windows; measure phosphine every two hours in the warehouse; take readings at the five points in the warehouse every day in the morning, and afternoon to test for evenness of concentration.

### 1.6 Warehouse Hermetic Sealing and Testing Conditions

Seal with plastic Films, sealing tape and glass plastic.

All grain ago, the various positions were Empty storage air tightness test. See table 2.

**Table 2. Measurement of warehouse air tightness**

| Bin NO. | storage situation | 500Pa to 250Pa half life mean(s) |
|---|---|---|
| NO.18 | empty | 60 |
| NO.21 | empty | 71 |
| NO.22 | empty | 41 |

## 2 Results and Discussion

### 2.1 Insecticidal Effect of Fumigation

After the fumigation, store inspection showed that the insects were all killed (Table 3). The caged insects were dead, whether those taken from or the or those taken from laboratory cultures. Because the samples stored a month in the laboratory on cultured food contained no insects, the fumigation was effective.

**Table 3. After the fumigation grain warehouses**

| Bin NO. | moisture % | temperature (℃) | germination % | pest condition (No./kg) grain plane | middle and lower layer |
|---|---|---|---|---|---|
| NO.18 | 12.4 | 25.1 | 84.1 | 0 | 0 |
| NO.21 | 12.7 | 25.2 | 85.6 | 0 | 0 |
| NO.22 | 12.5 | 25.0 | 86.3 | 0 | 0 |

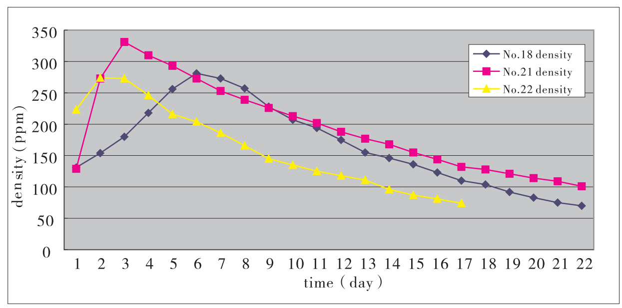


**Fig. 2 Curve of average concentration in warehouses NO.18, NO.21 and NO.22**

### 2.2 Phosphine Gas Concentrations

Figure 2 shows the average concentrations in storages 18, 21 and 22. In No. 22 and 18 storages initial circulation warehouses lasted 36 hours (No. 18 did not meet this standard due to equipment failure). This was followed by four hours circulation every morning (total circulation 60 hours after shutdown). The No. 18 positions did not quickly achieve the highest value. In No. 21, there was consecutive circulation 72 hours and no further circulation. The highest concentration depended nota only on the time and continuous circulation, but on the air tightness of the warehouse. No. 22 storage had the worst air tightness and the lowest phosphine concentrations.

Phosphine gas concentrations began to increase and then peak and decline. After it had declined to approximately 150 mL/$m^3$ (ppm), the rate of decline decreased. This has the following main aspects: First, as the warehouse and the circulation pipe forms a closed circulation system, the increase in pressure from the introduction of gas will cause losses. This raises the question of when to stop recirculation. Secondly, because the new warehouse wall is not very dry, this has increased phosphine adsorption; Finally, because the food itself has a large number of phosphine gas adsorption sites, a few days after the fumigation phosphine declines.

### 2.3 Initial Dosage is Reasonable

Phosphine fumigation circulation Technical Specification (Trial): fumigation concentration, when the average temperature in the grain is more than 25℃ and resistant insect species are present, maintain phosphine concentration at a minimum of 70 mL/m$^3$ (ppm). Use more than when the average temperature in the grain is below 25℃. When insect-resistant strains are present, maintain phosphine concentration at a minimum 100 mL/m$^3$ (ppm). Considering the stored grain pest density, type and the air tightness of the warehouse, and other factors, the low – dose fumigation is set in the concentration of 200 mL/m$^3$ (ppm). But in No. 21, because its good gas – tightness maintains phosphine a long time (more than 200 mL/m$^3$ (ppm) for 10 days), the initial concentration can be lowered to not less than 100 mL/m$^3$ (ppm). If results in No. 21 continues to confirmed, the fumigation outcome will be better. Although No. 22 has poor air tightness, the concentration was maintained above 70 mL/m$^3$ (ppm). Given this situation, the dose can be reduced by proper improvements.

### 2.4 The hermetic Quality of the Warehouse

The hermetic quality and, to a certain extent, the impact of fumigation is the key to success and, at the same time, will impact on the development of resistance to pests and environmental pollution. From the data in Table 2 it can be seen that warehouses pressure decreased from 500 to 250 Pa exceeded the technical specifications 40 seconds half-life. From 2.2 it can be seen, that with better air tightness and warehouses, effective concentrations can be maintained over longer duration. The poorer the air tightness, the greater is the rate of decline of phospine.

$$\text{decline rate}\% = [(C_{max} - CN)/C_{max}] \times N \times 100\%$$

$C_{max}$ of the highest average concentration; CN days for the fumigation of the average concentration of N, N the number of days for the fumigation

**Table 4. Degressive ratio & air tightness**

| Bin NO. | decline rate(%) | half life(s) |
|---|---|---|
| NO.18 | 16.5 | 60 |
| NO.21 | 15.3 | 71 |

### 2.5 Temperature, Moisture, Changes in Germination

The grain Heap surface temperature increased slightly, but the fumigation had little effect on temperature. After fumigant release there were some small local changes in moisture content, up or down, but no GRAIN partial condensation. The average moisture content did not change; moisture changes should be considered as normal water balance processes. Germination was slightly lower than before the fumigation. These results show that the test operating conditions and technology are feasible.

## 3 Conclusion

3.1 Low – dose circulation fumigation has provided a guarantee of success, if air tightness is good. Maintaining effective concentrations for a long time, inhibit the development of stored grain pests, and achieve100%

3.2 Stored Grain Pests generally occur in the hot and humid season, being influenced by warehouse temperature and humidity, but the experiment proved that, in this environment, circulation fumigation of food, has little effect on temperature and moisture, and will not lead to grain stack temperature and moisture changes.

3.3 Circulation for some time does not require daily circulation.

## Acknowledgements

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