

## Some Keys and Discussion about Recommended Regulation of Phosphine Fumigation for Chinese Grain Storage

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**Abstract:** A recommended state standard for phosphine recirculation fumigation in grain storage industry in china was made. The basic condition is required on gastightness, equipment, instrument and relative materials. The scheme should be made according to the condition of grain quality, insects and their resistance, stacking method, climate and temperature of grain, safety issues and so on. The monitoring on phosphine, concentration maintaining by fumigant reinforcing, and insect detection by test insect cages as keys are recommended during the fumigation. The dosage of tablets of aluminium phosphide is determined by the planned phosphine concentration according to the insect species, resistance, density of insect per kilogram of grain, temperature of grain, schemed fumigating time, gastightness et al. The process about tablet applying methods or phosphine generator operating, phosphine recirculation time, concentration monitoring time and some issues on fumigant distribution is suggested. On the other hand, the recommended data are effective for insect pest control in many cases. There are some technical issues which should be discussed due to a huge of changes happened in practice in last several years.

**Key words:** phosphine, fumigation, grain storage, regulation, China

### Introduction

Since 1998, A new type of horizontal warehouses had been widely used in state grain storage in china since 1998, which are 48 to 60 meters in length by 21, 24, 27 and 30 meters width and capable of holding a grain mass in 6 meters or more in height. And some huge squat bins and concrete silos had been constructed. These facilities were equipped with closed-loop fumigation (CLF) equipment for the effective phosphine distribution. The CLF system consists of some fixed or mobile pipes which were connected with the wall of storage by a sub-floor ventilation system. Phosphine-air mixtures can be recirculated through the pipes, ventilation ducts, grain mass and headspace in the storage<sup>[1]</sup>. In some cases, the top grain was sealed by plastics. Some piloting pipes were posted under of the plastic sheeting for fumigant so that there was no phosphine distributing in the headspace. The phosphine was usually applied in one of the following ways: one, aluminium phosphide tablets were placed on the surface of the grain mass; two, the tablets was dropped into water, and then phosphine with a few carbon dioxide was put into entrance of ventilation duct. The phosphine in the storage can be sampled by some sampling pipes located in grain bulk and

monitored by electronic monitor or detecting tubes. For the effective application of the CLF system and pest control, a recommended regulation of phosphine recirculation fumigation for Chinese grain storage industry had been made. There were still some problems in practical fumigation according to the results from a communication survey about phosphine fumigation which was carried out from 246 state grain depots, in 2005 – 2007 in China. In order to make the CLF system application and insect pest control be more effective, a recommended regulation of phosphine recirculation fumigation for grain storage industry in China was made, which mainly focusing on phosphine concentration, exposure time, phosphine applying methods, tolerance or resistance of insect to phosphine and so on.

### Phosphine Concentration for Fumigation

The phosphine concentration was the most important factor to kill insects, which not only depended on the dosage of applied phosphine or aluminium phosphide, but also on the gastightness of warehouse and other factors such as environment temperature, grain and so on<sup>[2]</sup>. In the standard the concentrations are suggested according to tolerance or resistance of insect to

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phosphine, temperature of grain and exposure time( Table 1).

**Table 1. Recommended phosphine concentration under different temperature and exposure time**

Species	Temperature** (°C)	Concentration in different exposure time( mL/m <sup>3</sup> )		
		≥14 d	≥21 d	≥28 d
<i>Susceptible pests-Sitophilus zeamais</i>	>25	200	150	100
<i>Latheticus oryzae</i>	20 – 25	250	200	150
<i>Tribolium confusum</i>	15 – 20	–	250	200
<i>Other susceptible species</i>				
<i>Tolerance pests-Rhyzopertha dominica</i>	>25	300	250	200
<i>Sitophilus oryzae</i>	20 – 25	350	300	250
<i>Tribolium castaneum</i>				
<i>Moths and other resistant species</i>	15 – 20	–	350	300

\*\* : temperature; point of pest exists in grain mass

The fumigation in most grain depots at the

recommended concentrations were effective in practice. But there were cases that the concentration is not big enough to kill insects completely. According to the survey from 246 grain depots, the survey results shew that the lowest phosphine concentration should be bigger than that in the table 2 [3]. As the data in table 2, the phosphine concentration killing all pests completely was changeable due to the insect tolerance, exposure time and practical storage. Generally, the concentration to kill pests completely in south china was bigger than the central or north one. That might be affected by the higher tolerance or resistance of insect to phosphine, the environment teperature, humidity, generations of insect reproduction, which were helpful for survival of insect after each fumigation in south China[4]. It indicated that the range of recommended concentration had significance effect for fumigation from table 2.

**Table 2. Lowest limitation of effective phosphine concetration in grain depots in China**

Depot name, Province	Lowest PH <sub>3</sub> (mL/m <sup>3</sup> )	Location in China	Depot name, Province	Lowest PH <sub>3</sub> (mL/m <sup>3</sup> )	Location in China
Huadu, Guangdong	350	South	Nanjing, Jiansu	400	East
Sanya, Hainan	200	South	Anqing, Anhui	300	East
Shenzhen, Guandong	300	South	Shanghai	300	East
Wuzhou, Guangxi	300	South	Wenzhou, Zhejiang	200	East
Beihai, Guangxi	200	South	Laiwu, Shandong	200	East
Nanning, Guangxi	300	South	Qingzhou, Shandong	250	East
Ningdu, Jiangxi	300	South	Rizhao, Shandong	150	East
Pingxiang, Jiangxi	200	South	Shenqiu, Henan	350	Central
Chenzhou, Hunan	200	South	Xuchang, Henan	200	Central
Hengyang, Hunan	300	South	Wuhan, Hubei	350	Central
Fuzhou, Fujian	200	Southeast	Macheng, Hubei	210	Central
Zhangzhou, Fujiang	250	Southeast	Nanyang, Henan	300	Central
Xiamen, Fujian	300	Southeast	Zhumadian, Henan	250	Central
Jintang, Sichuan	180	Southwest	Changechun, Jlin	100	North – east
Luzhou, Sichuan	260	Southwest	Nongan, Jilin	100	North – east
Zunyi, Guizhou	250	Southwest	Haerbin, Helongjiang	150	North – east
Kunming, Yunnan	180	Southwest	Mudanjiang, Helongjiang	160	North – east
Lanzhou, Gansu	150	West	Haicheng, Liaoning	200	North – east
Xi'an, Shanxi	100	West	Jianping, Liaoning	100	North – east
Dezhou, Shandong	150	East	Taiyuan, Shanxi	150	North – west
Jiana, Shandong	150	East	Xiangyuan, Shanxi	200	North – west

### Exposure Time

The grain can be stored for a longer time 3

– 5 years for wheat, 3 years for paddy. The recommended expsoure time of phosphine fumigation was more than 14 days, 21 days and 28

days respectively in the different condition including phosphine concentration, resistance level of insect, insect species and temperature. The time would be shorter or longer due to the different concentration of phosphine. Usually, the bigger was the concentration, the shorter was the exposure time. The higher level of phosphine is suggested for the serious insect existing, for that there were many lesser grain borers in grain mass at a high temperature. However, it was economic to maintain the phosphine at a suitable low concentration especially for less insects in the grain. In fact, it was not easy to know that insects were killed completely or survival in a sealed warehouse or grain bulk. To set insect cages was a useful method to detect the effect of fumigation according to the mortality of insects. Some authors had reported the practical exposure time in different cases<sup>[4]</sup>. It was seemingly needed much longer time to kill some special insects completely such as rusty grain beetle and psocids in certain level of phosphine. It was necessary that exposure time was more than 30 days under the concentration of 300 mL/m<sup>3</sup> or bigger<sup>[4]</sup>. Generally, the exposure time of phosphine for complete control in China was bigger than that of some published reports such as 6 – 9 days<sup>[5,6]</sup>, Price and Mills, 1988 and >7 days<sup>[9]</sup> Sayaboc et al., 1998.

### Phosphine Concentration Maintaining and Gastightness

In order to kill all pests during fumigating, maintaining effective concentration of phosphine was principal key in the whole process. There had been a requirement for gastightness, and the time to pressure decay from 500 Pa to 250 Pa was more than 40 seconds for horizontal storage, 60 seconds for squat bin, empty for vertical silos. It was recommended that the time to niuus pressure getting back from 500 Pa to 250 Pa was over 90 seconds for the storage sealed with plastic sheeting in flat warehouse. How to maintain the phosphine concentration was a difficulty in many fumigations, and it was mainly due to the gastightness insufficiency of warehouse. Phosphine supplement was a useful way of maintaining the concentration in production. Aluminium phosphide tablets were put into ventilation duct meanwhile CLF system was running. On-site phosphine generator was also used for fumigation.

### Resistance or Torlerance of Insect

There were a few research result on insect

resistance to phosphine around China<sup>[6,7]</sup>. And some other authors had given some reports on it. Most of resistance insects are from several provinces of south china. Some results had been given an output from programs cooperation between China and Australia on the project PHT9415, Phosphine resistance in insect pests of stored grain, and project PHT98 – 137, Integrating effective phosphine fumigation practices into grain storage systems in China, Vietnam and Australia. The relative results had been reported<sup>[7,8,10,11,12,13]</sup>. Yan et al (2005) had reported some on the latest development of it. According to the measurement, the resistance factor of rusty grain beetle was not too big in the species. But this beetle had a higher resistance than that of *Sitophilus zeamais* which was susceptible to phosphine<sup>[10]</sup>. So for the total population extinction in the case of insect pest existing in fumigation, relative tolerance has more significance than resistance perhaps. All above, it was difficult to know the real resistance or tolerance of insect to phosphine.

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