

## **PRE-FUMIGATION TO IMPROVE SAFETY AND EFFICIENCY OF PH<sub>3</sub> GRAIN TREATMENT IN THE VESSEL'S HOLDS DURING A VOYAGE**

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### **ABSTRACT**

The safety of the crew, and the effectiveness of phosphine fumigation of bulk grain in ships' holds at sea, can be ensured if leaks from the holds can be eliminated before fumigation. This can be achieved by a technique termed pre-fumigation. The basic principle of pre-fumigation is as follows: the empty holds are filled with insecticidal fog before loading. Subsequently the points of leakage of insecticidal particles onto the deck or to the working and living quarters are detected and located using special equipment. After the grain is loaded, and the fumigant products placed in the grain, marked leak points are then subjected to extra hermetic sealing. Trials conducted on-board the tanker/bulker vessel "Marshal Grechko" have shown that phosphine did not escape to deck areas from holds that had been pre-fumigated and sealed. However phosphine leakage was observed in non pre-fumigated reference holds.

### **INTRODUCTION**

In international transportation of grain by sea over long distances, preventative fumigation is frequently carried out with phosphine. The fumigant is placed in the grain in the vessel's holds at the port of loading, while exposure of the grain to the gas continues throughout the journey.

Two main problems must be resolved in this context:, namely the effectiveness of insect control, and the safety of the crew. Both objectives may be successfully achieved if phosphine leaks from the holds can be eliminated. Current practice is to decide whether or not the hold is sound for fumigation on the basis of a visual examination and the crew's knowledge of the general condition of the vessel. Such evaluation is subjective and

frequently leads to unsatisfactory results, and occasionally to tragic consequences.

We propose a procedure for the objective survey of ship holds involving equipment-based detection of locations of fumigant leakage, followed by subsequent sealing of leak points. This technique we term "pre-fumigation".

### **THE METHOD**

Pre-fumigation is carried out on empty holds before the grain is loaded. After a visual examination of the holds, any visible cracks, gaps, or openings are eliminated by sealing, and the hatches are closed hermetically.

The air-space of the hold is then filled with a mist of tracer-product using a fog generator. The main mass of this fog must be formed of droplets 10 to 30 microns in size.

The tracer-products used are composed of particles that are ionized when suspended in fog. Such products may be insecticides permitted for use as residual insecticides on stored-products. Use of an insecticide as a tracer has a double effect since it also ensures the elimination of insects from the hold's internal walls while residues on the hold's surfaces ensure protection against insects for prolonged periods.

Immediately after introduction of the fog into the holds, a technician inspects the ship with a special portable device. This incorporates an ionized particle detector and an aspiration pump for air sampling. When ionized particles are detected in the air, the detector emits visible and audible signals.

The most likely locations for phosphine leakage on a ship must be surveyed in this way. These are: the engine-room, under-deck and utility ways, forecastle areas, as well as the junction points between the individual hatches, between hatch and coaming, and hatch covers.

Points where leaks have been located are then marked, and their position recorded in the survey report.

Once the grain has been loaded and the fumigants have been introduced, the holds are closed and extra sealing is carried out at any point where leakage had been previously observed. This is done after the grain is loaded since seals at the juncture between hatches and coaming are broken each time the hatch is opened.

Studies were carried out on the effectiveness of pre-fumigation during a trial voyage made by the tanker/bulker vessel "Marshal Grechko" from New Orleans (USA) to Novorossiisk (Russia) in September/October 1991.

Four of eight holds were pre-fumigated. The remaining four holds were not pre-fumigated and served as reference holds. The holds were subsequently loaded with corn and fumigated with phosphine (aluminium phosphide pellets) according to a standard dosage of 0.83 g/m<sup>3</sup>. The pre-fumigated holds were then sealed at the points where leakage had been noted.

The effectiveness of the pre-fumigation was studied by analyzing phosphine present concentrations in the air at the external surfaces of the hatches where they meet the coaming, and also by measuring average phosphine concentrations in the intergranular air of the corn bulk at 6 points within the grain cargo. These points were: towards the top, mid-way, and towards the bottom of the grain bulk, both along the central vertical axis of the hold and near the hold walls.

## RESULTS

The results of measurements of phosphine leakage on deck through gaps (cracks), and junction points between hatches and coaming are given in Table 1. The figures in this table demonstrate that in holds 1, 2, 5, and 6, where pre-fumigation had been carried out, followed by extra sealing at detected leakage points, phosphine did not escape on deck throughout the entire exposure period. In holds 3, 4, 8, and 9, that had not been pre-fumigated, leakage of fumigant was detected on deck during the exposure period in three of the four holds.

Table 1: Phosphine concentrations recorded near hatch covers of the tanker/bulker "Marshal Grechko" after fumigation of pre-fumigated and non pre-fumigated holds.

	Hold number	Phosphine concentration (ml/m <sup>3</sup> ) near hatch cover after inception of fumigation	
		3 days	8 days
Pre-fumigation carried out	1	0	0
	2	0	0
	5	0	0
	6	0	0
Pre-fumigation not carried out	3	1	0
	4	0	0
	8	0.5	0.14
	9	2.0	0.30

The dynamic characteristic of average phosphine concentration in the inter-granular air in the experimental holds and in the control holds is shown in Table 2 and Fig. 1. It can be seen that in the pre-fumigated holds the average phosphine concentration remained constant throughout the whole period of exposure to the fumigant. In holds that were not pre-fumigated the phosphine concentration during the exposure period dropped both continuously and significantly.

Table 2: Average PH<sub>3</sub> concentrations in the intergranular space of holds fumigated with and without pre-fumigation.

Days after fumigant application	Average PH <sub>3</sub> concentration (ppm)	
	Pre-fumigation	No pre-fumigation
2	282	570
4	257	434
6	295	-
8	247	-
10	-	105
14	245	-

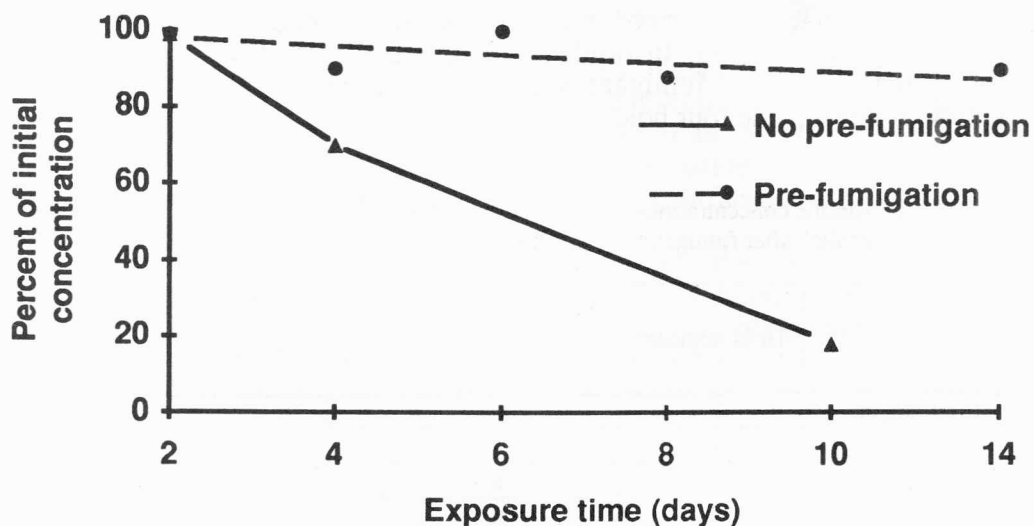


Fig. 1: Average PH<sub>3</sub> concentrations as percent of initial concentrations in the intergranular space of bulk corn in the holds of the tanker/bulker "Marshal Grechko".

The results obtained demonstrate that pre-fumigation effectively minimizes phosphine leakage from the hold interior on to the deck. Pre-fumigation enables to detect the leaks and thus to increase the efficiency of disinfection by appropriate sealing. This method guarantees effective insect control even at lower phosphine dosage rates. It can therefore be concluded that pre-fumigation enhances crew safety on ships carrying grain with fumigants applied on-board.