Technical Note 07

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Uniphos dosimeter tubes for fumigation monitoring

Phosphine Gas for Fumigation

Phosphine (PH_3) is one of the most widely used fumigants for disinfestation of agricultural commodities such as cereal grains, tobacco, spices, animal feed, cotton, wood chips and other stored products. Fumigation is carried out generally by producing Phosphine (PH_3) in situ by placing calculated amounts of solid aluminum phosphide in the fumigation enclosure. The solid reacts with the atmospheric and grain moisture to produce gaseous PH_3. When this method is followed, the PH_3 concentration starts building from zero and attains a maximum and then starts falling as the PH_3 generation stops, while the leaks from the enclosure and the absorption of PH_3 in the grain and other losses continue to slowly bring down the PH_3 concentration. Other sources of PH_3 include pure phosphine from a pressurized cylinder (used diluted with CO_2 or N_2) and phosphine generators, such as the Uniphos QuickPHlo-R.

Fumigation Dose

The fumigation procedure requires a certain concentration profile to be maintained during the entire period of fumigation to ensure total insect mortality. The insect mortality is governed by an entity called the 'fumigation dose', or PH_3 dose, which is defined as the concentration-time product expressed in ppm-hr, and also known as the "CT". Hence in order to determine the adequacy of the fumigation, it is necessary to measure the total PH_3 dose (CT) received by the commodity:

PH_3 dose = PH_3 conc.(ppm) x time (hrs) = ppm-hrs

For example, if your fumigation process uses 600 ppm PH_3 for 5 days, the dose would be:

600 ppm x 5 days x 24 hrs/day = 72,000 ppm-hrs

The concentration time product is equivalent to the area under the curve obtained by plotting the concentration vs. time. If the concentration were constant over the entire time, the calculation of the area would be a simple multiplication as in the equation above, as shown in Figure 1. However, if this quantity is to be measured when the concentration is not constant but varies over a wide range starting from zero, it is necessary to make several, on-the-spot measurements of gas concentration at regular intervals over the entire period of fumigation to generate the concentration vs. time curve to find out the area under curve (Figure 2). This involves several measurements and is time consuming.

Figure 1. Dose evaluation for constant concentration.

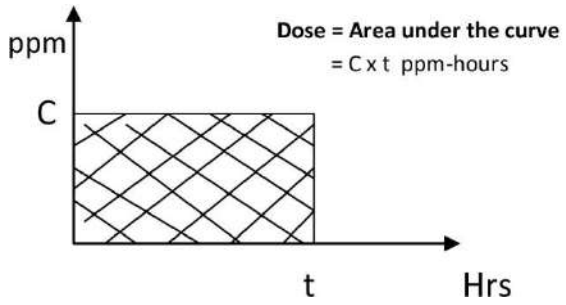
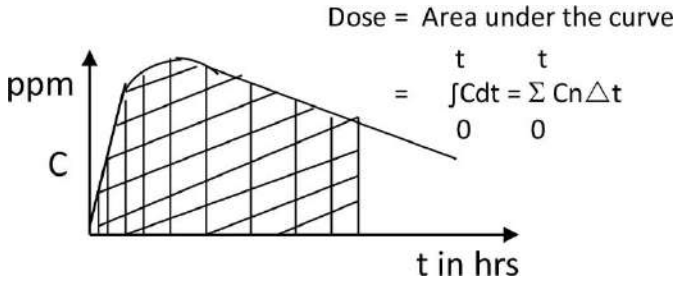


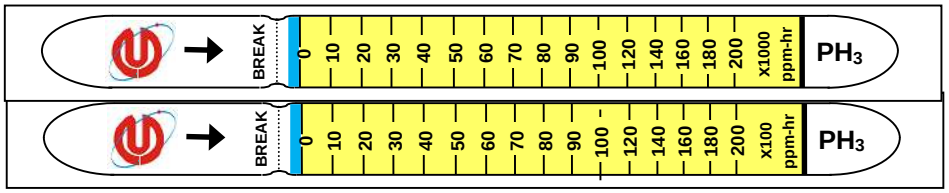
Figure 2. Dose evaluation for varying concentration.



Uniphos PH_3 Dosimeter Tube Description

The dosimeter tube described here saves time and money by measuring the total dose received by the commodity during the entire course of fumigation with a single measurement. The length of stain produced on the dosimeter is calibrated to read directly the phosphine dose received. The tube consists of a narrow glass tubing of about 4 mm OD and 3 mm ID with a length of about 15 cm filled with PH_3 sensing chemical. Both ends of the tube are sealed with round tips. The calibration markings of dose in terms of ppm-hr are printed on the tube. When the dosimeter tube is opened and placed in the environment containing PH_3, the phosphine gas diffuses in and reacts with the sensing chemical, producing a colored stain. The length of stain produced depends on the concentration-time product, i.e dose, which is expressed in ppm-hr.

Figure 3. Schematic diagram of an LPG-1 (top) and LPG-2 (bottom) dosimeter tubes for PH_3.



Uniphos offers two ranges of phosphine dosimeter tubes (See Figure 3):

LPG-1 for the measurement of higher doses of 1,000 to 200,000 ppm-hr.

LPG-2 for the measurement of lower doses of 100 to 20,000 ppm-hr.

How to Use Uniphos PH_3 Dosimeter Tube

1. Break the dosimeter tube at the scratch mark and place the longer portion containing sensing chemical within the fumigation enclosure at a representative location before starting the fumigation.
2. The tube can be placed either horizontally or vertically, but to avoid any spillage of chemical it is advisable to keep it in a vertical position with the open end facing upwards.
3. Take the tube out from the enclosure at the end of fumigation and read the PH_3 dose on the tube.
4. Multiply the reading by the factor printed on one end of the tube (1000 for LPG-1 or 100 for LPG-2) to obtain the total dose. For example, a reading of 20 equals 20,000 ppm-hours on LPG-1 and 2,000 ppm-hours on LPG-2.
5. If desired, calculate the average concentration during exposure as follows:

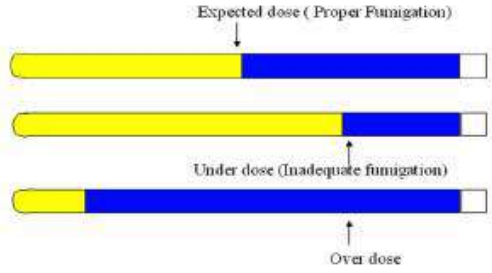
$$\text{Average Concentration (ppm)} = \frac{\text{Dose (ppm} \cdot \text{hrs)}}{\text{Exposure Time (hrs)}}$$

Determining the Adequacy of Fumigation

In a silo of a fixed volume and for a fixed volume of stored products and fixed dose, one can expect the same stain length for repeated fumigations (See Figure 4). This becomes a handy method for fumigators to ascertain the adequacy of fumigation and provide a proof of fumigation to their clients.

If in any experiment the stain length obtained is much smaller than the average stain length that one used to get, it is a sure indication that the fumigation has failed. The failure can be because of leaks, inadequate amount of fumigant or substandard fumigant material used.

Figure 4. Adequate and inadequate fumigation.



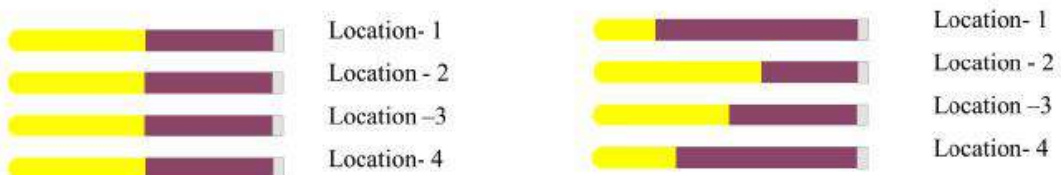
PH_3 Concentration Distribution

Often times although the total aluminum phosphide dosing is adequate, the PH_3 concentration distribution is not uniform for various reasons. At many places the PH_3 concentration can be very low and not adequate to kill the insects. This non-uniform distribution can be detected by measuring the PH_3 dose at several different locations with several dosimeter tubes. Non-uniform distribution will lead to widely varying stain lengths (doses), as shown in Figure 5.

Proof of Fumigation

The dosimeter tube which measures the PH_3 dose can be used as a proof of fumigation and also to ascertain that it is done properly. The stain length on the tube remains the same after it is taken out of the silo after the fumigation and can be produced as a proof.

Figure 5. Examples of uniform (left) and non-uniform (right) fumigant distribution.



For more information contact Uniphos Americas
Tel: 1-844-247-0450