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Automation of Phosphine Flushing after Completion of AlP Lot Fumigation

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Abstract: ***The paper aims at tackling the problem of human exposure to harmful phosphine gas after the removal of tarpaulin on the fifth day of lot fumigation. The fumigation activity was done using aluminium phosphide sachets. The deliverable has been achieved by pumping in fresh air using a centrifugal fan and a hose pipe inside one lot and the phosphine levels were monitored after the same. This method had dual benefits, firstly, scavenging the relatively denser phosphine gas and secondly flushing out phosphine gas from the tarpaulin sheets before lifting up the tarps manually. The method proved to be effective and thus, food handling industries can employ this method to minimize reliance on PPE while removal of tarpaulin sheets after fumigation of agro-based products.***

Keywords: Fumigation; A lP; aluminium phosphide; weevils; lot fumigation

1. Introduction

Lot fumigation is a worldwide popular technique employed to fumigate agro-based raw materials. In the warehouse, in which the trial was performed, the settlement was not air tight or leak proof and hence warehouse fumigation is not a good idea, as it can affect the factory workers in the vicinity. In case of lot fumigation, the lots of grains are covered with tarpaulin sheets and hence fumigated with minimal use of AlP. The phosphine gas released remains within the sheets, because we seal the sheets with sand bags and cello tapes/ velcros. The entire arrangement is kept undisturbed for several days, based on the regulatory guidelines to kill the pests based on the fatal dosage. The major risk is in the process of removal of tarpaulin, where, if a person without a PPE like SCBA (Self-Contained Breathing Apparatus) removes the tarps, he gets exposed to concentrations of phosphine as high as 400 ppm. The human TLV is 1ppm based on a 15minute exposure. Hence, rather than relying on administrative measures, one should resort to automation to totally eliminate human involvement during the tarpaulin removal.

The primary chemical reaction governing the release of phosphine from Aluminium Phosphide is as follows:

$$AlP + 3H_2O \longrightarrow PH_3 + Al\,(OH)_3$$

Hence, an RH greater than 50 is required for proper and quick release of PH_3.

2. Method and Materials

We have followed NSPM-22, the Indian regulatory guidelines for fumigation. The change control procedure was raised in Glaxosmithkline Consumer Healthcare factory, Rajahmundry, India. The type of tarpaulin was 200 gsm, LDPE. The material fumigated for the trial was 13MT of Skimmed Milk Powder (SMP). AlP in the form of powder in sachets was used, the total weight being 122grams of powder (Three 34 gram sachets and two 10 gram sachets). The lot was sealed using sand bags. The air pump was 0.5 HP, 2880 rpm pump with a flame proof covering. The centrifugal pump was kept outside the warehouse, with the PVC hose laid through a hole in the warehouse. The hose pipe was properly fixed under one of the pallets. All electrical connections inside the warehouse are removed to avoid any risks of fire (Phosphine is an extremely flammable gas).

Two sampling lines to monitor phosphine concentration were laid and passed through the same hole as the hose of the air pump. One sampling line at the bottom of the stack and another at the top of it. Before pumping the air on the fifth day, the exhaust fan of the warehouse was switched on so that once the air starts escaping the tarpaulin; it gets released into the atmosphere. No personnel entered the warehouse, because once the pump is switched on at t=0, the tarpaulin gets bulged with air and starts slowly leaking from the leakages in the tarpaulin, near the sandbag seals and the air from inside the tarpaulin can escape from any direction. Flushing of air on the floor level is again very beneficial because phosphine is generally denser than air and hence scavenging of the low lying air is good for effectively diluting the phosphine gas. The hose pipe used in this experiment had an outlet inner diameter of 40 mm. The pump used a centrifugal fan and the air volumetric was 36 CFM.

3. The Risk

Typically, every 34 gram sachet of AlP releases 11gram of phosphine and a 10 gram sachet releases approximately 3 gram of it. Below is a table exhibiting the variation in the concentration of PH_3 (phosphine gas) inside the tarpaulin over the trial period of 5 days (120 hours).

Many industries use AlP tablets instead of sachets but there is again a large magnitude of risk during putting the tablets, because they have to wrapped in a porous cloth before putting, so that the residual tablet does not fly off and stays in the cloth. During wrapping the tablets in the cloth, the operator runs at a heavy risk of inhaling a large amount of phosphine gas which is minimized on using sachets, because they can be pulled out of the container and immediately placed at the stack. The wrapping activity was completely eliminated. The typical concentration of PH_3 in a lot varies as shown:

Table 1: Trial using a one phase phosphometer at GSKCH Rajahmundry

Phosphine levels in ppm					
Time (24 hr format)	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
1030		650	832	590	409
1500		668	860	552	372
1800	37	672	842	503	331

4. Technical Risks in the Trial Setup

Since the air and trial hoses are laid right from the first day, there are chances of back flow of phosphine gas from the hose to outside the warehouse and hence, butterfly valves are fixed to ensure no leakages. Since phosphine is highly inflammable, it is important to make sure that no motor sparks are in contact with the gas directly. To avoid this risk, the pump motor has a flame-proof frame and the motor is kept outside the warehouse.

5. Observations

Weight of the stack: 13 Metric Tonnes.

Amount of AlP: 122 grams.

The handheld phosphometer was kept near an identified leakage in the stack and hence a low concentration of phosphine detected. Below is the concentration readings averaged for 30 seconds on every data point near the leakage:

Time (minutes)	Phosphine level inside the trial stack (ppm)
0	17
4	10
6	8
9	6
16	4
19	3
>20	<1

6. Results & Conclusions

By the above experiment it was proved that even by a low flow rate pump, the entire phosphine from inside the tarpaulin can be flushed out without a human entering the warehouse. The reduction in the risk levels was very high compared to the infrastructural modifications that need to be made in the warehouse. There can be future explorations whenever multiple connections are needed (to aerate multiple stacks/lots), by using a primary line with multiple outlet nipples with valves positioned according to the stacks. A ring blower can pump air at better rates using the same power. Possibilities of bidirectional air pumps, synchronized with 30 seconds of pumping in air and 20 seconds of suction, repeated harmonically for some time can also be tried for better results, because this alleviates the reliance on improper sealing of the stacks. An ideal CFM will vary according to size of the stack but a 100CFM air flow per stack will be an idea value (provided the practicality across warehouses).

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References

[1] NSPM 22: Guidelines for Assessment, Audit and Accreditation of Fumigation Agencies for Undertaking Aluminium Phosphide
[2] Qanoon H.A., Eachkoti R., Phaughat P. Treatment regimen for celphos poisoning, World Journal of Pharmacy and Pharmaceutical Sciences.
[3] Applicator's manual for Aluminum Phosphide Fumigant Tablets, Pellets and Gas Bags. WEEVIL CIDE.DOI=http://www.upi-usa.com/media/WeevilCide_Manual_ENGLISH.pdf

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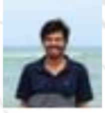

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