An outside-silo rubber bag phosphine generator for stored grain fumigation

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Abstract

There are various technological approaches of phosphine application for disinfesting stored-grain pests in silos. It has been over 20 years for the use of rubber bag-type outside-silo phosphine applicator in Beijing area, which is applicable for different types of storage facilities and containers. This paper gives a detailed exposition for the use in vertical silo fumigation including key technological points, technical specification and the measure of management.

Introduction

There are various technological approaches of fumigation to disinfest stored grain in vertical silos. This paper presents a generalization from the study of using rubber bag type outside-silo phosphine applicator, which has been used for over 20 years in Beijing area in practice. This method is applicable to all types of grain storage facilities and containers such as horizontal storages, vertical silos, steel bins, grain stacks and so on, while the use in vertical silo fumigation has been constantly studied and improved in the past 20 years. Currently in the Beijing area, this technology has become successful. The following is a detailed exposition.

The Principle of Operation

Drop tablet or pellet aluminium phosphide (Phostoxin) directly into the rubber vessel containing excessive water on which AlP reacts in the form of hydrolysis to produce mixed gas of phosphine, ammonia and carbon dioxide. Then the gas mixture is cooled off in the cooler and enters the grain mass through connecting tube, probing vent and the gas distributor.

As is known to all, the excessive water in the reaction vessel is conducive to absorb the produced heat for preventing phosphine explosion and the produced ammonium compounds will be solved in water so as to avoid the block up of the vent by solidified ammonium compounds. Then the gas mixture of phosphine and carbon dioxide with constant temperature can enter the grain mass. A homogeneous distribution of phosphine can be obtained by the existing air convection current in the silo.

The Module of the Applicator

The phosphine generator and the cooler

Both appliances are made of top-quality rubber that is acid and fire-proof in the form of bottles with neck (Fig 1). In original condition, the appearances of both are more like empty bags. The maximum bearing pressure of them is 0.25 kg/cm².

![Diagram of phosphine generator and cooler](image-url)

The phosphine generator

Height 1100mm, upper mouth diameter 200mm, bottom diameter 600mm. At 800mm above the bottom, there are two gas vents parallel to each other and connected with the connecting tube.

The cooler

Height 1100mm, top diameter 200mm, bottom diameter 400mm. The rest is the same as that of the phosphine generator.
Other necessary accessories

The wheeled rack of the generator and cooler consists of the vehicle body, top clip and middle clip.

The tube inserting machine mainly consists of base frame, body, tube clip and hand wheel.

The connecting tubes are hard rubber tubes with diameter 25mm.

The probing tube is seamless steel tube with diameter 25mm or 28mm. The length of each type is between 1000mm and 3000mm with thread screw at either end.

The distributors are also probing tubes with apertures (diameter 2 - 2.5mm) evenly distributed round and connected with probing tube at either end.

Technological Process

The technological process is illustrated in Fig 2.

Methods and Procedure of Application

Seal up the silo to meet the requirement of gas-tightness and prepare all of the materials and instruments.

Press the distributor into the grain mass manually or by machine according to the planned spot. Under the conditions while the grain temperature is higher than that of outside air, the distributor should be located at the bottom or both the bottom and middle, conversely, it should be done at the top or both the top and middle of the grain mass. The spot of top distributor is 300 - 600mm in depth from the surface of the grain mass, the bottom spot is 1000 - 2000mm above the bottom of grain mass. While the outside air temperature is 6°C or higher than grain, the distributor may be located at one spot, 300mm in depth from the surface of the grain which can be inserted by hand. In this case, multispot application may be done and the dosage of each time should be less than 1.5kg. If the tube inserting machine is used, be careful enough to keep the machine horizontally and the tube vertically.

Seal up all the openings after checking if the connecting tubes and the probe tubes are connected tightly and if the unloading opening and other parts meet the sealing requirement.

Fill the generator and cooler with water respectively. Then fasten the middle clip of the generator and the top clip of the cooler, connect the generator and cooler with a connecting tube, as well as the cooler with the connecting tube from the silo. Open and put the planned dosage of ALP into the generator and fasten its top clip. Check every joint again to make sure that there will be no gas leakage under certain pressure. Usually the tap water is applied. The proportion between ALP and water is

When the dosage of ALP is less than 1kg

\[ \text{ALP} : \text{reaction water} : \text{cooling water} = 1 : 4 : 4 \] (by weight)

When the dosage of ALP is more than 1kg

\[ \text{ALP} : \text{reaction water} : \text{cooling water} = 1 : 6 : 6 \] (by weight)

Care must be taken that the weight of ALP put into the generator each time should be not more than 2kg.

Unfasten the middle clip of the generator and drop ALP into the water. Generally the reaction starts within 5 - 10 minutes and ends within 30 - 60 minutes. Avoid racking and shaking at the beginning of the reaction. When the reaction is ended, press the generator and cooler to remove all the gas in it.

Disassemble all joints and fasten the opening of each tube. The tube inserting machine may be disassembled any time. Convey the generator and cooler to the designated place for residue treatment.

Generally the exposure period is 3 - 7days.

Dose Rate and Other Points for Attention

In common practice, the dose rate is 3 - 6g/m³, which depends upon the species and density of infested insects and the grain temperature.

The proportion of ALP to water must be accurate, otherwise, the speed of reaction would be too fast or too slow. Too fast reaction would cause explosion or other problems. In summer, the temperature of water should not be higher than air temperature. In case the reaction goes on
too fast or stoppage of the tube arises, take any one of the connector of the cooler apart immediately and connect it to a reserved tube for the fumigation of another silo. Inspect the cause of the accident as soon as possible and get rid of it in time.

The temperature difference between air and grain was 2 - 4°C lower than the highest temperature of a day and the average temperature of grain mass. An experienced method of calculating this temperature difference is that the upper aperture of the distributor should not be less than 200mm downward from the surface of the grain mass. It is strictly forbidden to release phoshine to the upper layer of grain while the grain temperature is higher than that of air. The effective area of apertures on the distributor must be at least 5 times the area of tube opening. Generally, 2.5mm of each aperture diameter are appropriate.

Over three fumigators including experienced director for every fumigation are required. More than two bottles of chemical-powdered fire extinguisher and gas masks are also necessary.

Management of the Applicator

The wheeled rack of the generator should be protected from rain and sunshine. Check the clips carefully before using. The rubber bag of the applicator and the cooler along with the rubber connector should be placed in shade and dry places to avoid deterioration. The use of denatured bags is prohibited. The tube inserting machine should be disassembled and oiled in time, especially oil those parts such as the upper and lower chain shaft, slide bush and chain to avoid rusty.

References

Wu Zengqiang, Yang Yang, Zhao Baohua and Zhang Yongquan 1990, A Trial of the application of aluminum phosphide powder during grain loading Grain Storage, 19 (1) 45 - 50p (In Chinese)