THE "DETIA BAG BLANKET", ITS USE AND APPLICATION

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ABSTRACT

The "Detia bag blanket" fumigation technique has been developed for the fumigation of huge quantities of stationary bulk grain without the necessity of circulation for fumigation and with a minimum of labour and cost.

Each blanket consists of a gas permeable plastic non-woven material containing 100 Detial fumigation bags (Detia Gas-Ex-B) and it liberates about 1.13 kgs of phosphine.

After the bag blanket is unrolled on the surface of the grain, moisture is absorbed and the liberated phosphine is able to penetrate the grain mass up to a depth of 30 metres. This fumigation technique is successfully used in shipholds, steel tanks, concrete silo bins, bulk storage warehouses and bunker storages under plastic sheets. The penetration time can vary with the different kind of storages as is shown by concentration/time tables. Lethal concentrations can be measured at the bottom of the grain storages in 3 to 10 days. The dosages vary between 0.5 grams (bunker storage, Australia) and 28 grams of phosphine per ton of grain (bulk storage, Germany). Depending on prevailing conditions the exposure time should range between 8 and 20 days.

INTRODUCTION

The "Detia bag blanket" fumigation technique has been developed for the fumigation of huge quantites of bulk grain with a minimum of labour and cost and without the necessity of circulation for fumigation. A bag blanket consists of a gas permeable plastic non-woven material and is about 5 m long with 100 Detia fumigation bags in two rows.

The bags that make up the blanket are well known under the trade name "Detia Gas-Ex-B"; they have been used for the treatment of bulk grain for many years. Normally they are probed singly into the grain to a depth of 3 - 4 m, with two workers being required to make the application. However, if the quantity of grain is more than 10,000 tonnes it becomes more and more problematic to finish the application before hazardous concentrations of phosphine gas are liberated from the bags. Therefore the Detia bag blanket has been developed for rapid application to overcome this hazard and to reduce labour costs.

Each bag blanket is packed as a roll in a gas tight metal can. For

application the blanket is removed from the can and unrolled on the surface of the grain. As moisture from air and from the grain is absorbed by the formulation about 1.13 kg phosphine per blanket is liberated. Because phosphine is a small molecule with a density similar to air and because of its high vapour pressure at room temperature (35 bar) it penetrates rapidly and deeply through the interstitial air of the grain kernal into the grain mass.

Since phosphine is almost insoluble in water and does not react with the chemical components of the grain it will be nearly completely desorbed after a relatively short period of aeration. No appreciable residue of the fumigant is left in the fumigated grain if the degassed bag blankets are removed.

Within the last two or three years the Detia bag blanket fumigation technique has been successfully used in shipholds, steel tanks, big and wide concrete silo bins, bulk grain storage warehouses and bunker storages under plastic sheets.

SHIPHOLDS

The fumigation of ships in transit is restricted to bulk carriers and tankers. For the application of the blankets in shipholds it is useful to charge them with grain in order to keep them in their original position even in heavy seas. Concentration measurements have shown that the phosphine will penetrate through 19 to 20 metres and arrive at the bottom of the hold in about 7 days (Leesch et al 1978). This gives an average penetration time of about 3 metres per day.

STEEL TANKS

Similar results were observed in a steel tank with a capacity of 14 000 m^3 (400 000 bushels) (Allen et al 1979) The dimensions of the tank were 30 m (100 ft) diameter, 15 m (50 ft) sidewalls and 20 m (65 ft) peak. Since phosphine is a space fumigant the total volume of the tank was used to determine the quantity of fumigant required.

The chosen dosage was 3.5 Detia fumigation bags per 28.3 m^3 (1 000 ft^3) which corresponds to a phosphine dosage of approx. 1.4 grams PH_3 per cubic metre. For the whole tank 18 Detia bag blankets were applied. These blankets were simply unrolled down the grain slope. The average outside temperature during the exposure period was only 11°C.

Table 1 shows the phosphine concentrations between 1 day and 17 days of exposure in the different places of the tank. The deepest sampling point was 13.7 m (45 ft). A lethal concentration of 160 ppm was observed at this point on the 5th day. On day 9 the average concentration observed was about 600 ppm. The average penetration time was almost 3 metres per day.

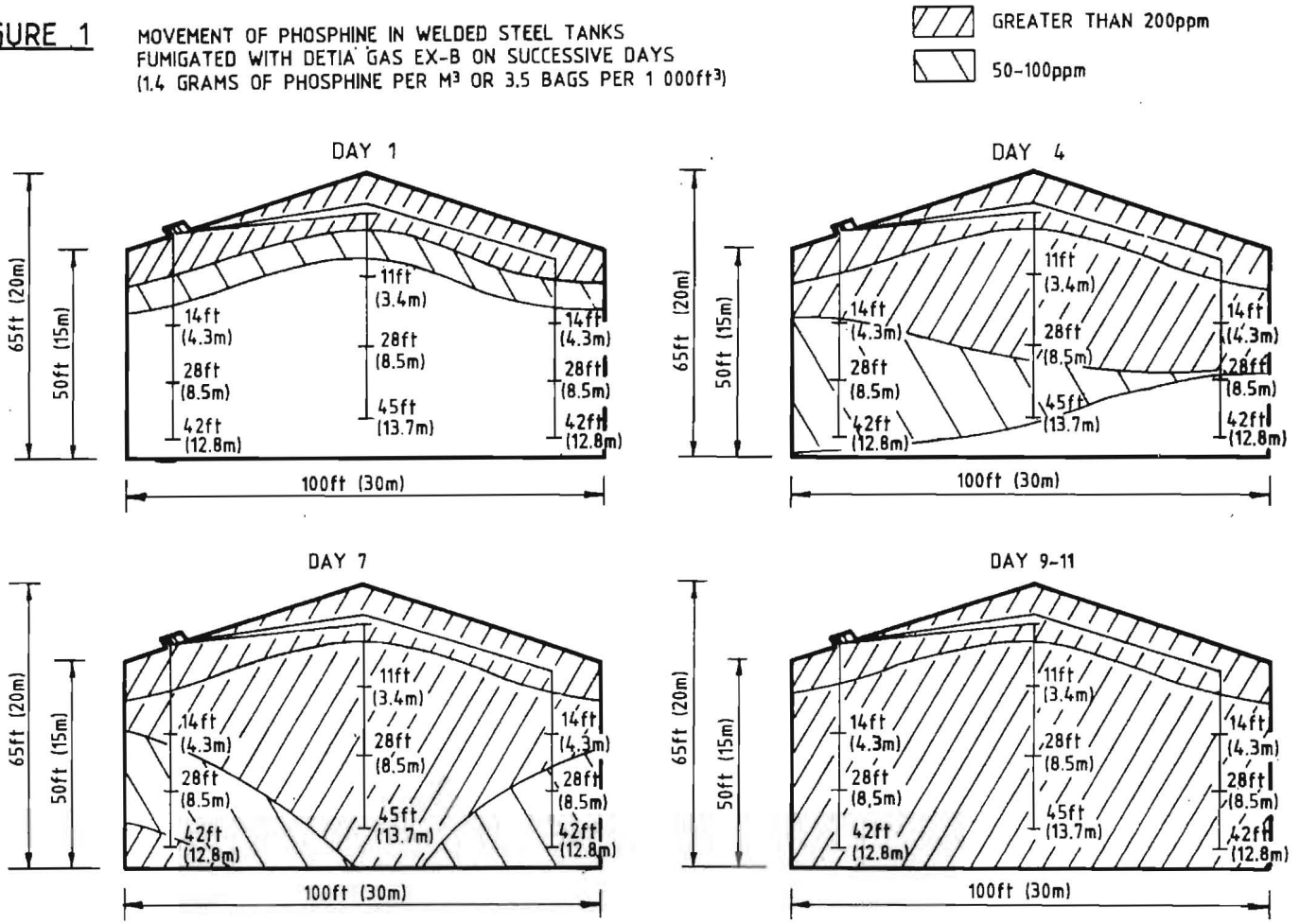
TABLE 1 PHOSPHINE CONCENTRATIONS IN WELDED STEEL TANK (400,000 BU.)
FUMIGATED WITH DETIA® GAS EX-B (3.5 BAGS PER 1000 CU. FT.). (1,4 GRAMS OF PHOSPHINE PER M^3)

PHOSPHINE CONCENTRATION (PARTS PER MILLION)

Exposure Period (Days)	CENTER				SOUTH SIDE			NORTH SIDE				Sampling Point ← Depth
	Over-space	3.4m (11 ft)	8.5m (28 ft)	13.7m (45 ft)	4.3m (14 ft)	8.5m (28 ft)	12.8m (42 ft)	4.3m (14 ft)	8.5m (28 ft)	12.8m (42 ft)	Aeration Duct	
1	1875	t[1]	0	t	20	t	t	1350	t	t		
2	2940	460	75	t	65	0	10	1455		5		
3	3150	770	600	5	105	5	t	2640	10	10		
4	3375	1800	900	60	200	25	50	1515	20	40		
5	2700	705	1300	160	600	60	75	1200	40	50	390	
6	1830	1250	990	350	520	100	140	1300	50	90	650	
7	1650	1300	1650	550	700	160	200	1300	100	120	900	
8	1275	1230	1250	710	400	240	280	1000	180	190	1020	
9	930	825	925	730	350	320	400	910	230	270	910	
10	930	710	760	1150	575	410	490	825	285	250	875	
11	870	600	750	800	640	490	500	710	350	340	800	
13	700	550	725	580	390	40	280	605	410	415	540	
15	490	375	425	500	205	140	150	270	300	240	490	
17	390	265	205	450	345	255	280	345	320	305	295	

ace concentrations of Phosphine - less than 5 ppm.

FIGURE 1 MOVEMENT OF PHOSPHINE IN WELDED STEEL TANKS FUMIGATED WITH DETIA GAS EX-B ON SUCCESSIVE DAYS (1.4 GRAMS OF PHOSPHINE PER M^3 OR 3.5 BAGS PER 1 000ft^3)



The movement of phosphine in such welded tanks can be demonstrated by the schematic drawings of the tank shown in Figure 1. The light hatchings indicate the concentrations between 50 and 100 ppm and the heavy hatchings above 200 ppm. The different sampling points are marked with their depth in feet and metres. As can be seen, after 9 days the concentration of 200 ppm is exceeded on all sampling points. After 17 days the concentrations are still between 205 and 450 ppm.

CONCRETE SILO BINS

In many countries there are big concrete silo bins with a capacity between 2 000 and 4 000 tons. Since all of them are filled after the harvest there is no possiblity to move the grain into an empty bin if fumigation is necessary. Therefore the only possibility is a surface fumigation.

It has been shown by several test fumigations in USA and Zimbabwe that the Detia bag blanket technique can be used for this purpose successfully. However it seems that a certain proportion between diameter and height of the silo bin should not be exceeded. Good results have been obtained with a proportion of 1 : 2. When this proportion exceeds 1 : 4 or 1 : 5 the concentrations that can be attained at the bottom of the bin become increasingly smaller. If it becomes 1 : 10, as in small German silo bins, concentrations of more than 2 ppm will not be attained at the bottom of the bins even after two weeks.

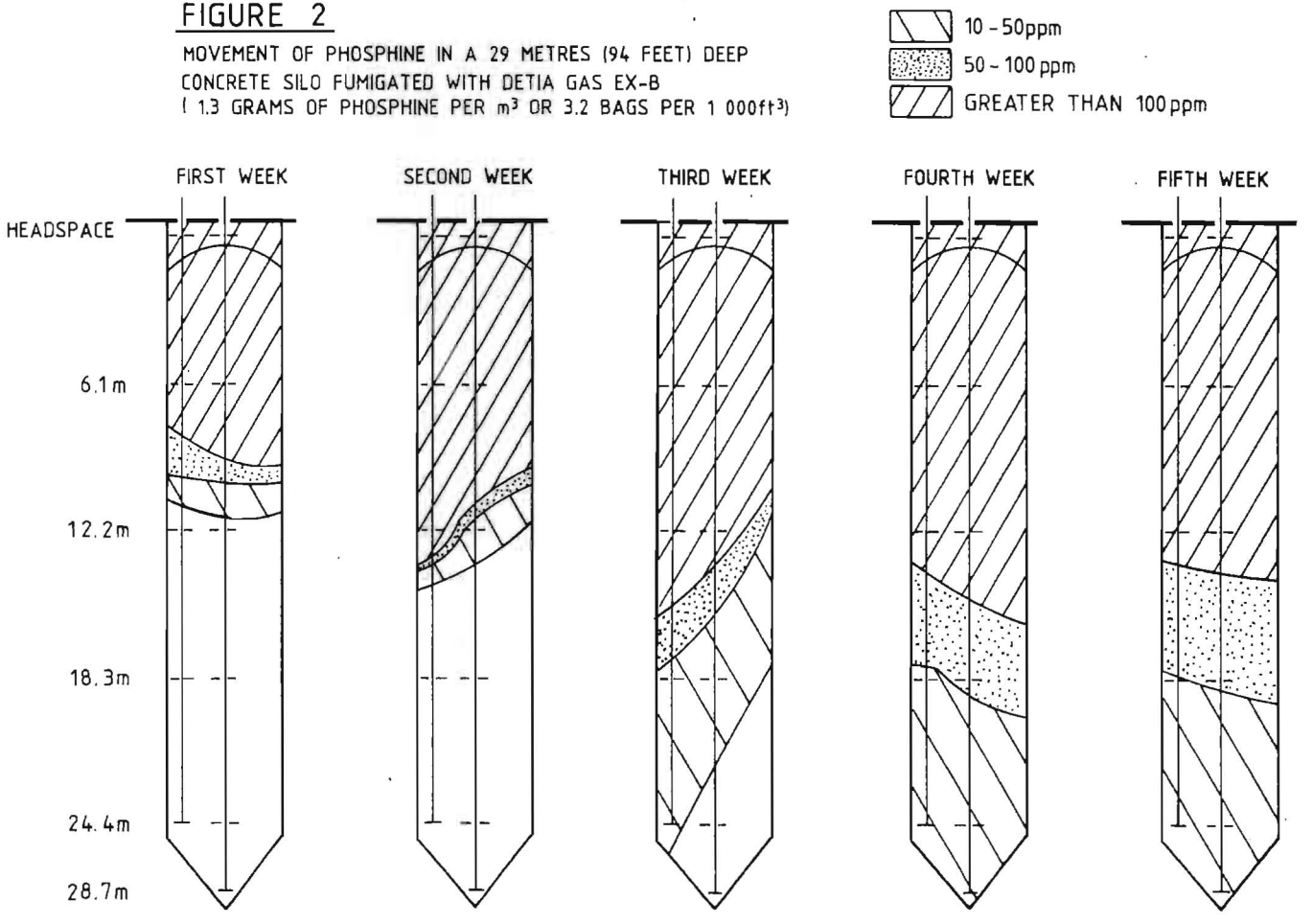
In Zimbabwe a concrete silo bin filled with 3 600 tons of maize was fumigated with 700 Detia fumigation bags (i.e. 7 Detia bag blankets were unrolled on the surface of the grain to give a dosage of about 1 bag per 5 tons or 1.5 grams of phosphine per cubic metre). The bin measured 15 m (diameter) by 30 m (high) to give an almost ideal proportion of 1 : 2. The headspace above the grain was about 1 m and gave an empty volume of about 180 cubic metres.

The highest concentration observed in the headspace during the test was 3 600 ppm after 1 day of exposure. After 10 days the concentration at the bottom of the bin exceeded 50 ppm. The highest concentration at the bottom was 450 ppm after 18 days of exposure and the concentration in the headspace at this time was still more than 800 ppm. (Caley 1981)

Distinctly different was the result in an American silo bin where the diameter was 7 m and the height 29 m, with the proportion between diameter and height of only 1 : 4. Using a dosage of 3.2 Detia bags per 1 000 cubic feet (1.3 g PH_3/m^3) it took 27 days to establish concentrations over 20 ppm at the bottom of the bin. Therefore the average penetration time was only 1

FIGURE 2

MOVEMENT OF PHOSPHINE IN A 29 METRES (94 FEET) DEEP CONCRETE SILO FUMIGATED WITH DETIA GAS EX-B (1.3 GRAMS OF PHOSPHINE PER m^3 OR 3.2 BAGS PER 1 000ft^3)



metre per day in this bin. During the following 10 days the average concentration at the bottom was 30 ppm. According to Lindgren and Vicent (1966) and Reynold et al. (1967) such concentrations are sufficient to kill immature stages of various pests if these concentrations can be kept over a longer period of time. The highest concentration in the headspace, was about 3 000 ppm and after 5 weeks it was still above 200 ppm.

The schematic drawings (Fig. 2) show the movement of the gas during five weeks of exposure.

BULK GRAIN STORAGE WAREHOUSES

In bulk grain storage warehouses in Germany and other European countries where large quantities of grain between 5 000 and 20 000 tons are stored the heights of the grain layers vary in most cases between 2 and 5 metres. It has been found that the fumigant can be applied most effectively by covering the blankets with a 5 to 10 cm layer of grain and placing polyethylene sheets on the surface. The liberation and the distribution of the gas under the plastic sheets are then more uniform, the storages have wooden sidewalls covered with plastic sheets in order to prevent gas from escaping. The dosage used in Germany is much higher than in other countries due to the severe climatic conditions and the low temperatures of the grain. An application of 2 ½ Detia bags per ton (28 g of phosphine per ton) with an exposure time of 2 weeks for grain between 9 and 15°C will kill all immature stages of insects present in the grain. The penetration time of the phosphine is about 4 - 5 m per day.

Several tests with wheat, barley, oats and maize have shown that the penetration time is in the same range for the first three grain types but it is significantly shorter for maize.

In tests with maize, concentrations at the bottom of the grain mass exceeded 2 000 ppm but for wheat, oats and barley it was between 300 and 700 ppm after 2 days. Directly above the plastic sheets concentrations of 100 to 300 ppm were measured. This indicates that large quantities of phosphine can penetrate the thin polyethylene sheets to escape into the empty space above the grain. In laboratory tests a new plastic sheet, a polyethylene sheet impregnated with a layer of polyvinylidene chlorides, was found to be reasonably impervious to phosphine. According to these test results the penetration is about 100 times smaller than that of a simple polyethylene sheet.

A fumigation test in a warehouse with bag blankets under these special sheets resulted in much higher concentrations in the grain with the same dosage and exposure time. The concentration at a depth of 4 metres was about

5 000 ppm after 2 days and still 1 500 ppm after 8 days while in the headspace concentrations up to 30 ppm were measured. All of the test insects including the immature stages were killed after 14 days.

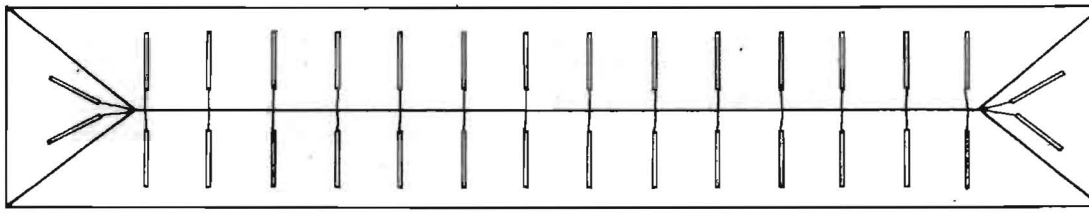
BUNKER STORAGE

In countries where the climatic conditions allow a temporary grain storage in large heaps of grain stored in the open air or underground, the Detia bag blankets can also be used. In the case of Australian bunker storages the grain is only 1 m or 1.5 m underground and is "enveloped" in thick PVC-tarpaulins. The dimensions of these bunkers can be up to a height of 11 metres, 50 metres in width and 100 to 150 metres in length with capacities between 10 000 and 60 000 tons of grain.

For the application of the Detia bag blanket a horizontal slit of about 25 cm is cut into the tarpaulin about 2 metres down from the crest of a bunker. With an iron rod the blanket can be pushed through this slit down the slope of the grain and then the slit can be sealed with a small piece of tarpaulin and glue. Since the PVC-tarpaulins are relatively gas-tight and the exposure time is measured in months, it is possible to use a very economic dosage. Moreover the relative high contents of carbon dioxide in these bunkers (up to 5%) has a synergistic effect on the phosphine. In one test only 29 blankets (about 0.5 g PH_3/ton) were necessary to fumigate a bunker system containing 60 000 tons of wheat (Fig. 3). The whole fumigation procedure was finished in a very short time with only two or three labourers.

FIGURE 3

DISTRIBUTION OF DETIA BAG BLANKETS IN A PVC COVERED BUNKER SYSTEM (60.000 TONS)



The distribution and effectiveness of gas in such bunker systems has been investigated and published by Banks and Sticka (1981). Their results show that within 3 or 4 days insecticidal concentrations of phosphine penetrate to the bottom of the grain. The lowest concentration they found was in one corner of the bunker. Nevertheless a Ct product of 20 gh per m^3 could be achieved over 28 days and none of the caged insects survived at this place. In these tests a phosphine dosage of 0.75 grams per ton was applied.

In Argentina, so called "silos subterraneos" where the grain is stored below ground level, have been successfully fumigated with the Detia bag blanket fumigation system.

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