USE OF A MICROPROCESSOR-CONTROLLED SENSOR-LINKED DOSING SYSTEM TO REGULATE APPLICATION OF FUMIGANTS TO STRUCTURES AND ENCLOSURES

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One of the most difficult areas for finding a suitable replacement for methyl bromide is that of mill fumigations in temperate climates. Methyl bromide (MB) became the fumigant of choice for treating mills, because it had a rapid action, was a good penetrant, did not react with any structural materials as a gas, as well as being non flammable and effective against a very wide range of pests. For flour mills, the cost of production losses per day are likely to far exceed the cost of the fumigation itself, and so a replacement method needs to have a rapid action. MB, and the gas it replaced for this use 35-40 years ago, hydrogen cyanide, are both able to give results within 24 hours. There is opposition among millers in Europe over using phosphine as an alternative, and another proposed alternative, heat treatment, is not suitable in many old buildings. Some countries may ask for mill treatments to be classed as a critical or emergency use of MB, and this course of action will become more likely each time moves to bring forward use reduction and phase-out dates are accepted by the Parties to the Montreal Protocol. Although structural fumigation is a minor use area in terms of the total MB market, more of the gas applied is emitted to the atmosphere from these treatments because there is little scope for sorption and reaction. There is thus a strong case for research to reduce MB doses and emissions from this area.

An automated, sensor-controlled dosing system suitable for use with a pressurised supply of MB has demonstrated the capacity to compensate for leakage in mill fumigations, improving efficacy and achieving moderate dosage reductions over conventional dosing methods which introduce most gas at the start of fumigation. Any system which offers increased efficiency in dosing with one fumigant is likely to be of value to others. Replacing the thermal conductivity sensor used for MB with an electrochemical cell, phosphine fumigations of bulk grain have been conducted using the microprocessor-controlled dosing system, achieving better gas distribution and improved efficacy.

Mill treatments: - Five mill fumigations have been monitored, three (A-C) using the new dosing system and two (D and E) using conventional methods. In normal practice most fumigant is added at the start with the option of topping up later as the concentration falls. A minimum MB concentration-time product (CTP) of 200 mg.h/l is recommended. In mill A a higher dose was applied including a top-up of gas, the system controlling only the last part of the treatment. In one of the two conventional treatments (D), weather conditions were so calm that no top-up was needed.

For mill treatments gas is introduced at more than one level in the mill, but mostly to the upper floors. Usually a circulation system is provided by a fan linked to wide layflat polythene tubing which blows gas from the ground floor to the top floor. When the automated dosing system was used to control the treatments in mills B and C, the initial dose was reduced to less than two thirds of the usual level for the mills and fans were used only during the first hour. All subsequent dosing of gas was supplied by the system. A sample of gas was drawn from each area in sequence via nylon-6 gas sampling lines (2 mm bore) through the thermal conductivity sensor. The microprocessor compared the sampled MB concentration with a preset threshold level for dosing, and any area with less gas than the set point received a pre-programmed dose of MB. MB was supplied by 9.5 mm nylon dosing lines controlled from a rack of solenoid valves interfaced with a pressurised MB cylinder. The sequence was repeated continuously until a time set a few hours before the end of the fumigation.

Doses applied and the CTP's obtained are given in Table 1 and gas concentration profiles on the top floor of the mills are shown in Fig. 1. The automated dosing system enabled less gas to be used because the extra gas to compensate for unpredictable weather effects no longer had to be added, and initial gas concentrations were lower. At the end of fumigation, gas levels were always higher where the automated system had been used. There was little variation in the CTP's obtained in different parts of the building with the automated dosing system. The automated system has potential for use in structures with any other fumigant.

<u>Phosphine trials in bulk grain</u>: - With the impending loss of MB as an alternative, phosphine is increasingly relied upon for the protection of durable commodities, notably cereals. Phosphine is usually applied to bulk grain as solid formulations of aluminium or magnesium phosphide which break down to release phosphine gas. The control of resistant strains and stages require long exposures which in leaky bins and floor stores are hard to achieve because solid formulations soon finish breaking down and have no more gas to release. In order to input gas continuously, independent lines of research in the UK and Australia turned to the use of a cylinder-based supply of 2% phosphine in methyl bromide, culminating in the development of the Australian SIROFLO system and the UK sensor-controlled dosing system described here.

The different systems have been compared in the UK firstly in an 11 metre tall 780 tonne capacity bin of milling wheat, and more recently at the CSL floor store at York. The silo bin was prepared by shrink wrapping the auger entering the bin at the base, applying a modified cover to the aeration duct inlet, and sheeting the grain surface after insertion of gas sampling lines and thermocouples at various positions. Applying gas to the base of the silo, the continuous flow strategy was tested first without recirculation. The distribution of gas to the grain surface at the top of the bin was slow, there being little differential between ambient and grain temperatures, reducing the stack or chimney effect often encountered in tall structures (Fig. 2).

The SIROFLO system achieved an even distribution of gas within 24 hours and maintained even concentrations throughout the trial period (Fig. 3). In fact the system was designed to cope with less well sealed conditions and in this trial more phosphine gas was expended using this system. The sensor-controlled system using recirculation achieved an even distribution of gas after three days and thereafter a minimal gas input maintained adequate gas concentrations throughout the treatment (Fig. 4). The system offered an economical dosing method for phosphine on grain. Similar results are being obtained in the floor store trials.

Table 1. Doses applied and concentration time products (CTP) obtained from sampling points at five mill treatments; A-C using the automated dosing system, and D-E using conventional methods

Mill	Volume (m^3)	Dose applied (Kg) Initial	From system	CTP obtained (mg/l x h) Range	n	Mean $\pm$ S.D.
A	3142	109	24.5	297-547	10	378 $\pm$ 65
B	2037	49.5	50.7	188-289	13	262 $\pm$ 30
C	4197	91.0	28.8	250-298	9	281 $\pm$ 15
D	1813	59.0	-	282-309	4	300 $\pm$ 12
E	4200	204	-	388-723	6	512 $\pm$ 131

Fig. 1 Methyl bromide concentrations at top floor in mill fumigations

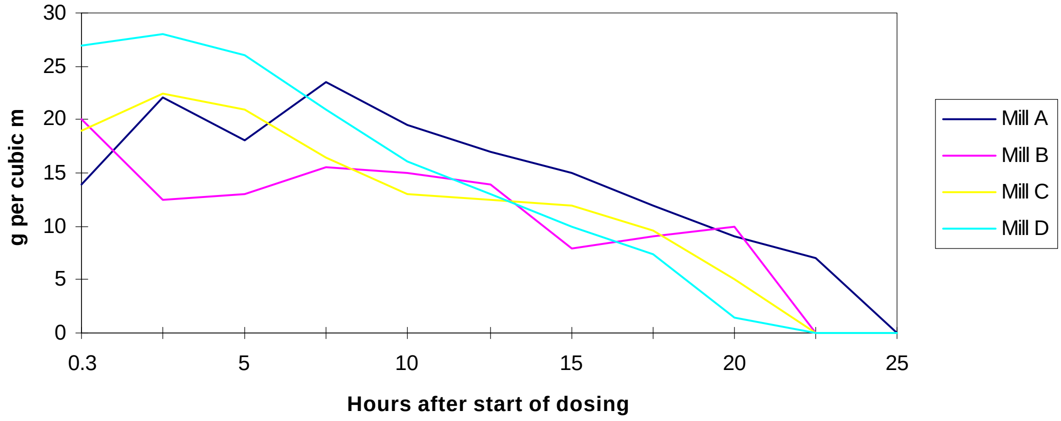

Fig. 2 Continuous flow from base without recirculation: Phosphine levels 1m under sheet in bin

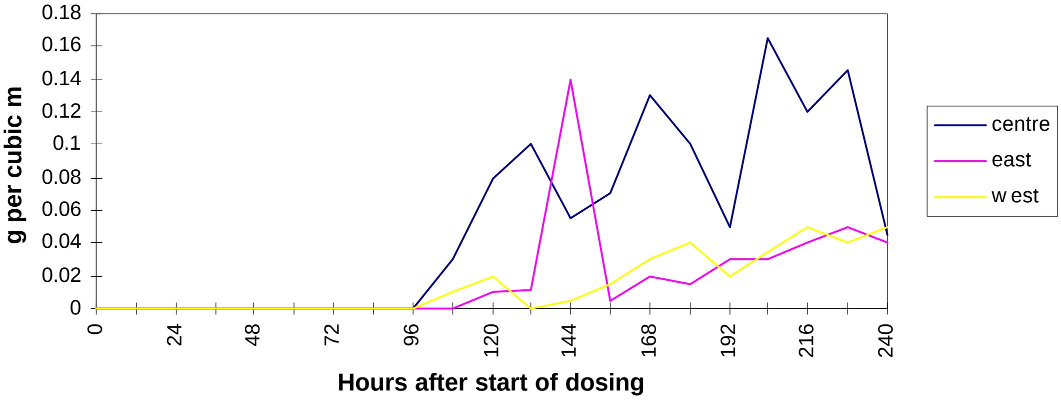

Fig. 3 SIROFLO* system: Phosphine levels 1m under sheet in bin

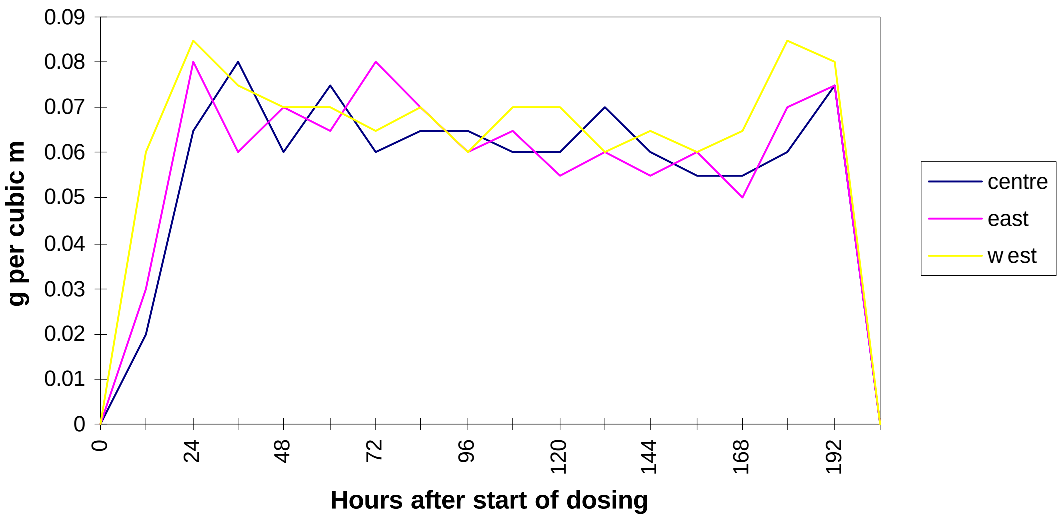

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Fig. 4 Sensor system with recirculation: Phosphine levels 1 m under sheet in bin