Nitrogen treatment of grain, Newcastle Grain Terminal

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Abstract

Controlled atmosphere treatment of grain is a relatively old, but proven technology. This paper explains GrainCorp's experience on design, installation and use of nitrogen at the Newcastle Grain Terminal.

GrainCorp and the Stored Grain Research Laboratory conducted feasibility trials on the use of nitrogen in 1992. The trials were quite successful and gave GrainCorp the confidence to commission a relatively large-scale treatment plant.

The nitrogen treatment plant was commissioned in 1993 and covers 16 × 1800 t bins. Nitrogen is supplied as a bulk liquid under pressure. This is vaporised and supplied to each bin via a fixed pipeline system.

To date, over 300,000 t of grain have been successfully treated and exported (with no Australian Quarantine and Inspection Service (AQIS) rejections) from the nitrogen plant.

Nitrogen has proven to be very useful at the Newcastle Grain Terminal. It combines low capital cost with moderate operating costs to provide a versatile and effective treatment solution. Nitrogen caters for both contact-pesticide residue-free and organic grain markets and can be a useful alternative to conventional treatments.

Introduction

Controlled atmosphere treatment of grain with nitrogen (N_2) is a relatively old, but proven technology. GrainCorp's Newcastle Terminal was faced with the challenge of providing a grain management method that was affordable, useful and practical.

Trial work was done in 1992 by the Stored Grain Research Laboratory and GrainCorp on two bins. These bins were originally designed for use with methyl bromide, however they were never used for that purpose. The trials were quite successful and gave GrainCorp the confidence to commission a relatively large-scale treatment plant.

Nitrogen, when used for controlled atmosphere treatment, can be generated from sources such as membrane systems, pressure-swing absorption or by use of liquid N_2 (see Cassells et al. 1994).

Liquid N_2 was chosen at the Newcastle Grain Terminal as this was the most economical means of supply, and also had the advantage of rapid (several hours) time to purge the bins as opposed to the longer purge times of alternative systems.

Why nitrogen was used at the Newcastle Grain Terminal

Low capital costs: the piping network needed to deliver N_2 during its purge and maintenance phases consists of galvanised pipes and a small shedder plate located in the bin bottom. The entire system was built for less than $20,000. This compares favourably to the cheapest fumigation options of Siroflo® or re-circulatory phosphine at several hundred thousand dollars.

Moderate operating costs: a 4-week treatment costs about 65 cents per tonne. This covers labour, materials (N_2) and equipment (tank and vaporiser) hire. This is more expensive than most phosphine treatments and fractionally more expensive than methyl bromide.

Worker access remains unhindered: access for maintenance and cleaning operations to areas that are undergoing N_2 treatment remains unhindered. Conversely, where fumigants are used, worker access is denied and can only occur under the supervision of a qualified fumigator, often necessitating the use of respiratory protection.

Suitable for a wide range of applications, N_2 is acceptable to all customers/markets. It is effective as a disinfestation treatment, with standard treatment rates providing complete kill of all stages of all species of insects. N_2 is also useful for grain maintenance, allowing stored grain to be kept free from insect attack or development before shipping. This avoids bin test turning which costs in excess of $1.00 per tonne (based on cleaning, maintenance, labour and power overheads).

N_2 provides true pesticide and fumigant residue-free grain, which makes it suitable for treating or maintaining organic grains.

No airing is required after treatment. Bins that have less than 1% oxygen (O_2) can be shipped with no registrable oxygen depletion to the workspace area. Conversely, fumigated bins always require ventilation before release.

N_2 is safer and less complex than conventional fumigation systems. There are no licensing requirements for personnel that perform N_2 treatments, however personnel must be trained and suitably skilled to undertake such work.

N_2 has no environmental impact. N_2 is 'borrowed' from the atmosphere and returned to atmosphere as a result of treatment.

There is no sorption of grain when treated with N_2, whereas there is always a degree of sorption when grain is fumigated.

There is no effect on grain viability when treated with N_2, whereas viability is usually affected when grain is fumigated with methyl bromide.

Operating overview

The silo complex was built in 1972 and consists of 40 × 1800 t capacity bins and 27 × 400 t capacity interspace bins. The complex was built from reinforced concrete and was designed as a sealed bin situation with gas seal valves at the bin bottom. However, there were only two bins that had fumigation capabilities. These bins were originally set up for methyl bromide but were never used.

The nitrogen treatment plant was commissioned in 1993 and covers 16 large bins. For the bins to pass the pressure decay test of at least 5 minutes duration (full bin), the bin wall to ceiling joint needed to be resealed with flexible membrane. After resealing, the bins easily passed the test.

Nitrogen is supplied as a bulk liquid under pressure. This is delivered by road and is stored in a 20 t capacity tank (Figure 1). The liquid N_2 is passed through an electrically-driven, fan-forced vaporiser, then supplied to each bin via a fixed pipeline system. The vaporised N_2 is then introduced to the bin bottom via a small shedder plate that is located in the bin bottom, above the slide on the outloading valve.

Figure 1. The Newcastle nitrogen treatment plant showing the 20 t tank that serves the closest 16 large bins.

Each bin is protected from inadvertent over-pressurisation by a simple, water-filled polyvinyl chloride (PVC) pipe pressure relief valve located at the bin top.

Key techniques

Vaporised N_2 is introduced rapidly into the bottom of the bin. This purges air out of the top of the bin through the open personnel access door. The purge phase is terminated when there is less than 1% O_2 in the bin.

The personnel access door is then closed and a small valve opened at the bin top. O_2 levels are maintained in the grain at less than 1% by 'trickle feeding' the N_2 through a small flow-meter into the bin bottom (see Figure 2). This process places the bin under slight positive pressure for the exposure period.

Figure 2. The under-bin pipeline system, with the Pest Control Officer adjusting the maintenance flow of nitrogen through the flow-meter.

Treatment options

Figures 3 and 4 show options for disinfestation and grain maintenance treatments (derived from Annis (1994)). Figure 3 shows the number of days of exposure and grain temperatures required for complete disinfestation of all species. Figure 4 shows the time required to return to pre-treatment levels if no insects were initially detected at various grain temperatures. This can be useful for determining grain maintenance strategies.

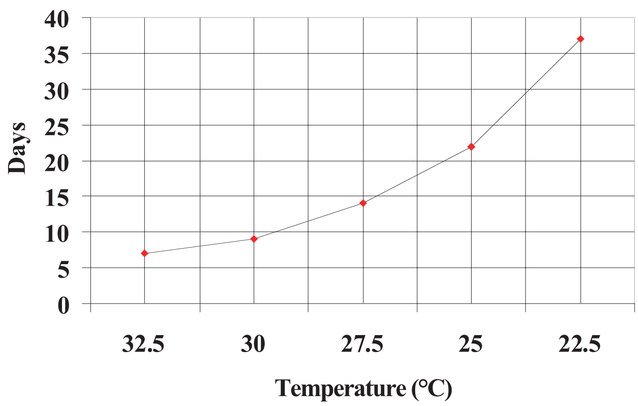

Figure 3. Number of days of exposure and grain temperatures required for complete disinfestation of all species, using <1% oxygen.

Nitrogen can be useful for insect control where an inexpensive supply of the gas is available. In the Newcastle Grain Terminal situation, a relatively inexpensive liquid supply was available from a nearby air separation plant. In remote locations, other forms of N_2 may be more appropriate.

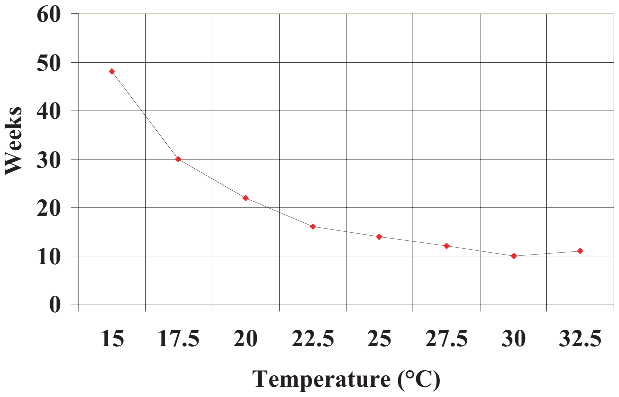

Figure 4. Time necessary to return to limit of detection if no insects were initially detected at various grain temperatures, after treatments as in Figure 3.

For disinfestation purposes, grain needs to be relatively warm (typically more than 20°C): the warmer the grain, the shorter the required exposure period (and smaller amount of N_2 used). At lower temperatures, a very long exposure time is necessary for complete disinfestation where tolerant pests and stages are present, such as *Sitophilus* pupae.

In relatively well sealed, full bins. This means that less air has to be either displaced from the bin or kept from invading the bin, therefore less N_2 is used for both the purge and maintenance phases.

Future N_2 use at the Newcastle Grain Terminal

N_2 continues to provide a useful grain maintenance and treatment system at the Newcastle Grain Terminal. To date, over 300,000 t of N_2-treated grain have been successfully treated and exported (with no Australian Quarantine and Inspection Service (AQIS) rejections) from the nitrogen treatment plant.

The remaining 24 large bins in the complex are to be sealed and the piping network extended to give 72,000 t of N_2 capability.

Reference

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