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SEALED STACKS: A PROGRESS REPORT ON THE TECHNOLOGY

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ABSTRACT

Sealed stacks fumigated with carbon dioxide have been accepted, and are used, as one of a range of methods for storing milled rice in Indonesia. Experience gained with the technique there has indicated a need for some improvements to meet operational requirements in commercial application. A major constraint has been gas loss through punctures made in the floor sheet when pallets are placed on it. Trials with reduced dunnage indicate that the quality of grain stored directly on the floor sheet remains unimpaired. In Australia the technique is being modified by using mechanical methods for sealing the cover sheet to the floor sheet. Adaptations are needed to permit application of the technique in situations where fork lift trucks are used to handle commodities packed in boxes or cartons. This report presents results of these recent modifications to the technique.

INTRODUCTION

Sealed stack storage (Annis *et al.*, 1984) has been adopted, and is used, as one of a range of standard techniques for storing milled rice by the National Logistics Agency (BULOG) in Indonesia (Nataredja and Hodges, 1990). However, a major constraint has been loss of carbon dioxide (CO_2) through holes in the floor sheet. These punctures, made when pallets are placed onto the floor sheet, are a potential problem identified by Annis and van S. Graver (1990). About 25% of the sealed stacks built in East Java have been punctured in this manner. This has resulted in much time and money lost attempting to rectify the problem. In some cases it has been impossible to gas stacks because they could not pass the pressure test (Conway *et al.*, 1990).

A trial was undertaken to investigate the feasibility of reducing the dunnage used under the stacks. This was considered because the plastic floor sheet prevents moisture migration through the floor into the bottom layer of

bags, and because in sealed stacks the pallets provide a plenum for introduction of CO_2 during gassing and play no role in ventilating the rice during storage.

The only problem that might occur, was that of moisture condensation due to temperature differences between the floor and the bottom layer of bags. It was calculated that this would be unlikely to lead to a moisture increase exceeding 0.5% in the bottom layer. As BULOG procures rice at, or below, 14% moisture content (m.c.) and as milled rice can be safely stored up to 14.5% m.c., it was considered unlikely that this increase, if it occurred, would be a problem.

In Australia physical methods (rather than bonding with solvent glue) for sealing the cover and floor sheets together have been tested. Sealed stacks are also being adapted for commodities packed in cardboard cartons and wood cases, which are handled and stacked mechanically. Floor sheets have suffered considerable damage, when loaded fork lift trucks have been driven over them to stack such commodities. As in Indonesia, repairs have entailed considerable time, effort and lost productivity, and it has been impossible to gas stacks due to the extent of puncturing. To eliminate the need for floor sheets in these situations, proposals to seal storage floors are being investigated. The cover sheets would then be fastened by physical means directly to the sealed floor.

METHODS

Indonesia

A trial was undertaken to investigate the effect of reducing the number of pallets at the GBB complex at Buduran, where three test stacks were built with one, three, and seven pallets extending from the front of the stacks along their longitudinal axes. In the last case, the pallets extended along the full length of the stack.

Grain samples were taken from all three stacks before they were sealed and gassed, and again from the same bags when the stacks were opened. The rice in all three test stacks had been held in storage for 10 months. However, the duration in sealed storage under CO_2 was 8 months for the stack built with one pallet and 5 months for the other two. Samples were also taken from the bottom layer of bags of sealed stacks built conventionally, with full dunnage, and treated with CO_2.

Two preference tests were carried out. The first to identify major differences between the initial and final samples, and the second to judge the small differences between them. In the latter, the samples were presented to permit concentration on colour and texture, the quality factors considered most important in this test.

Australia

In situations where sealed stacks may be opened and sealed frequently, a physical method of making the seal between the cover and floor sheets was tested as an alternative to using PVC solvent glues (Annis and van S. Graver, 1990). The method adopted involved use of square section mild steel tubing.

After covering the stack the sheets were trimmed to leave a skirt 0.5 m wide around the stack. The sheets, which were not folded back or doubled, were sandwiched between lengths of tubing. The tubing was laid along the outer edge of the skirt so that 0.5-1.0 cm protruded beyond the sealing tubing. This was placed so that cut ends only overlapped at the corners of the stack, elsewhere they were over- or underlaid by a continuous length of pipe. The tubing and sheets were held together, under pressure, by clamps bolted to the floor.

Small obvious gaps in the seal at the corners, where the piping met at right angles, were filled and sealed with silicone sealant. Any other gaps were similarly sealed along the outside edge of the clamped piping. The stacks were then pressure tested to check for leaks.

RESULTS AND DISCUSSION

Indonesia

A very small reduction in the quality of the rice in the layer of bags stacked directly onto the floor sheet was observed. However, this decline in quality was not considered to differ significantly from that of grain stored under CO_2 and stacked conventionally, on dunnage.

It was noted that the gassing process remained unaffected by the reduced plenum volume beneath the dunnage in the three test stacks. However, in stacks where the bags are stacked more tightly, with every layer locked, it is very likely that the rate of gas application would have to be reduced.

In view of the operational advantages of working with reduced dunnage, it was recommended that stacks with only a single pallet at the front of the stack should be built. However, the quality of the grain in the bottom layer of bags should continue to be monitored to ensure the efficacy of this variation to the technique.

Australia

The stacks sealed physically with square section tubing passed the pressure test with little further remedial sealing. However, considerable tension was placed on the sheets as they were drawn towards the stack during testing under negative pressure. This tension was sufficient to break the silicone sealing at one of the corners. This was remedied by more liberal application of silicone sealant. Pressure testing was resumed successfully after the sealant had set. Similarly during gas addition, the corners of the

enclosure were again observed to be under tension, though no rupturing or leakage occurred.

Where sheets are sealed with PVC solvent glues, they are free to move in response to the increasing vacuum during the pressure test, and rest against the sides of the stack. During gassing they flex and expand as the enclosure is purged with carbon dioxide, with the greatest stresses occurring at floor level in the corners. In the physically sealed enclosures, where the sealing was immovably fixed to the floor there is an additional force acting on the sheets that can act to rupture them. In this case where the enclosure was made from heavy duty membranes, no tearing occurred. However, in continuous operation the useful life of the enclosures can be expected to be reduced.

The physical system of sealing was well received by the work force, which objected to the odours associated with the solvents in PVC glues. It is planned to further test this procedure; using enclosures with narrow skirts (approx. 30 cm) with the physical seal anchored to the floor, using enclosures with wide skirts (0.5 m) with the seal anchored about 25 cm from the edge of the stack so that the membrane can flex, and with a wide skirt whose seal is not attached to the floor.

It was observed that the floor sheets could be severely damaged as loaded fork lift trucks were driven over them while stacking commodities packed in cartons and cases. The repairs associated with this puncturing involved considerable loss of productivity. In this application, elimination of the floor sheets and physically sealing the enclosing cover sheet to the treated floor would make the technique more appropriate.

Several methods for sealing and rendering floors gas tight may be considered. These include the silo sealants developed in Australia, use of acrylic based or oil based paints, waxes dissolved in solvents, etc. However, to be successful the method should be cheap, durable and easily applied.

CONCLUSION

Use of sealed plastic enclosures is being extended from commodities stored in bags to those stored in cartons, boxes and other containers. As the technique is adopted, it is being improved in existing applications, and modified to meet the varying operational requirements in its new applications. The technique remains comparatively easy to implement and provides an accurate but practical means for predicting the outcome of a fumigation.

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