Grain Covering Beyond 2010

Megan Equid

Jeremy Leggoe
School of Mechanical and Chemical Engineering

David Cripps
CEED Client: Co-operative Bulk Handling

Abstract

A 2009 WorkSafe investigation into the tarping practices employed by Co-operative Bulk Handling (CBH) on their Open Bulkheads (OBHs) unearthed some significant safety issues. The working conditions coupled with the heavy nature of the tarps have contributed to two deaths in Australia in the past 12 years, in addition to countless unreported injuries. CBH are therefore looking to improve their method of tarping OBHs. This project aimed to develop an innovative technique for covering grain that eliminates the need for workers to be on the grain stacks, while continuing to meet the requirements of being food-grade, impermeable and weatherproof.

Following the development and review of a range of concept designs, a new grain covering method has been compiled that involves deploying and joining sections of UV-stabilised LDPE material using extruded plastic 'joiner track' sections. With the aid of two loader cranes, this technique will allow all manual labour related to the grain storage to be conducted from ground level. Accordingly, the risk of personal injury due to the positions of personnel on the OBH during grain covering should be eradicated if the design recommendations proposed are advanced and later implemented by CBH.

1. Introduction

Co-operative Bulk Handling are a Western Australian based grain organisation who receive, store and handle approximately 95% of WA's grain harvest each year. They own and operate 196 receival sites across the state's grain belt and have the capacity to store up to 16 million tonnes of grain at any time. Around 70% of this grain is kept in Open Bulkheads (OBHs) and this proportion is increasing due to the low capital outlay associated with this open grain storage. The bulkheads range in length from 150 to 430m and are 35m wide, surrounded by walls of between 1.2 and 2.1m in height. When filled, the stacks can be up to 11m tall and hold around 110 tonnes of grain per metre width (Mr D Cripps, 2011, pers. comm., 8 March).

1.1 Current Tarping Process

Material Covers

PVC tarpaulins have been used by CBH for many years to cover their OBHs and the use of this material is widespread across Australia. These heavy-duty tarps have initial dimensions of 41x24m before they are cut down to more manageable 41x12m lengths. Each of these smaller sections weighs around 300kg, or 600g/m^2, and with regular maintenance (to patch holes etc.), they are designed to last in excess of three years. The PVC content of the tarps means that they are not suitable for recycling and they cannot be disposed of in landfill.

Figure 1 The current tarps and deployment method (CBH 2011).

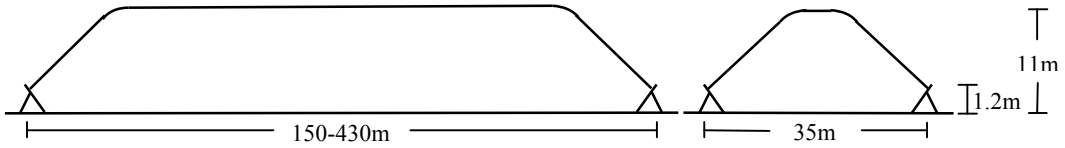

Figure 2 Approximate dimensions of the OBHs.

Deployment

To position the tarps, they are first lifted onto the peak of the stack by a Hiab (a small loader crane) before they are spread down the stacks and pulled across the OBH. Five people should be involved in this process, however it is often conducted with only three. The entire OBH must be covered when poor weather is forecast to minimise product loss. This means that staff are required to manually pull the leading tarp on and off the stack during grain receival and outloading: a cumbersome and dangerous process, especially during strong winds.

Joining & Sealing

Adjacent material sections are joined by sewing and painting. Although effective in ensuring the seam is waterproof and gas tight, this practice is time consuming and results in material losses (the seam has to be cut off each time the tarps are removed, so they become narrower with use). To seal the cover along the bulkhead walls, each tarp is pulled tight and wrapped around a metal bar with the plastic Canvacon material that is used to line the bulkhead walls. This bar is then clamped in place and the process repeated for each subsequent tarp.

Fumigation

All grain that is received must be fumigated with phosphine for insect control purposes. This process involves inserting a calculated dose of aluminium phosphide tablets into the vents in the bulkhead walls. During the 14-day fumigation period, the OBHs must be completely sealed and no personnel are allowed within 3m of the grain stack. Re-fumigation is required only when the grain has been stored in the bulkhead for more than 60 days.

1.2 Project Background

As noted through the tarping process summarised above, grain covering is a particularly labour intensive process that has a high personal injury rate. This statement can be backed up by the two tarping related deaths that have occurred in the past 12 years: one last year in Geelong, Victoria, and the other in Beaumont in WA's southeast in 1999 (WorkSafe Victoria 2010, WorkSafe WA 2001). Furthermore, WorkSafe and DuPont recently conducted a safety review of CBH's tarping process and, following this review, CBH were strongly advised to develop new methods of covering their grain in OBHs.

1.3 Project Objectives

The key objective of this project was to propose a new technique for covering grain that is stored in OBHs. Specifically, the covering method (defined as the material and the related deployment mechanism) has to meet the design requirements without relying on workers being on the grain stacks, i.e. all manual labour must be completed from ground level.

The design requirements set by CBH are as follows:

- It must be possible to fully enclose and seal the grain stack for fumigation purposes;
- The material must be food-grade, weatherproof and animal proof;
- It must be possible to uncover and re-cover sections of the grain stack at short notice;
- The design must be cheaper to implement and maintain than building and fumigating a shed or similar permanent structure.

An additional design constraint, set by the author, was that the new design must work with the current bulkheads and be adaptable to future changes to these bulkheads. Setting this constraint ensures that if the design recommendations made in this project are followed up with detailed design, the proposed covering method can be implemented over a short-time period with limited changes necessary to CBH's equipment.

2. Design Process

The initial concept designs were split into two categories: (1) designs that are unconventional compared to the current grain storage method and (2) the designs that aimed to improve this traditional approach. Jessica Equid, the other student working on this design problem, chose to pursue the path of spray-on foams. In the interest of providing CBH with two contrasting proposals, this project has focused on developing a more conventional covering technique.

As described, the information gathered from CBH and research conducted during the literature review highlighted that open grain storage in Australia is typically approached in the same manner: folded sections of plastic are manoeuvred on top of the stack by a Hiab-type vehicle before they are spread along the grain. Although the PVC tarps used by CBH fall into this category, they are by no means the extent of the design possibilities. A range of potential material options and deployment and joining methods were considered, as outlined below.

2.1 Material Options

Various materials were put forward for the grain stack covers, with their key features and properties weighed up against the material design criteria. Sailing cloth and shade sails were the first materials that were researched. A wide array of woven and laminated products is used in the sailing industry to manufacture sails and spinnakers. These materials are high strength and lightweight; however, they lack the required waterproof, gas tight and UV resistant properties (Doyle Sailmakers 2009). Similarly, high-density polyethylene shade cloth fell short of the design requirements (Polyfab Australia 2011).

Research then shifted to focus on different forms of polyethylene. Shrink films are a type of LDPE commonly used as covering materials since they can be welded and shrunk when high temperatures are applied, thus creating a close-fitting, water and gas tight cover. The toughness of the films is questionable as multiple layers of material are often used; this would greatly increase the difficulty and cost of the covering operation (Under-Raps 2011). To

achieve the high strength and toughness required for this application, a multi-layered product was found that contains three layers of LDPE and two layers of polyester reinforcement. The Griffolyn T-90 material, manufactured by Reef Industries in the USA, is UV stabilised and, as shown in Table 1, it meets all the specified material design criteria.

	Sailing cloth	**Shade sails**	**Shrink-wrap**	**Griffolyn T-90**
- Weight	Lightweight	Lightweight	Lightweight	Lightweight
- Waterproof	No	No	Yes	Yes
- Gas proof	No	No	Yes	Yes
- Toughness	Poor	Moderate	Moderate	Good
- UV performance after 2 years	Poor	Good	Good	Good
- **Material design criteria met?**	**No**	**No**	**No**	**Yes**

Table 1 Comparison between each material and the design critiera.

Thus Griffolyn T-90 has been chosen as the most suitable material to replace the PVC tarpaulins that are currently used by CBH. Its properties have been summarised below.

- Weight	300g/m^2
- UV resistance	Resistant for 30-48 months of outdoor exposure (dependent on colour of outer layer)
- Recyclability & disposal	Can be recycled through bulk plastic recycling operations or disposed of in landfills
- Safety	Contains no toxic chemicals and is safe for handling

Table 2 Properties and features of Griffolyn T-90 (Reef Industries 2011).

2.2 Deployment & Joining Methods

Following material selection, the next stage in the design process involved investigating a range of joining and deployment options. Each of the proposed designs was developed to suit sections of material that are joined to form a complete cover. These sections are envisaged to be 41x12m, equal to the dimensions of the current tarps but half the weight. A width greater than 12m was not considered due to increased handling difficulties.

As with the material options, a wide range of concepts were explored in order to develop a suitable method of placing the material sections on the stacks that does not rely on manual labour on the OBHs. One option was the installation of a permanent structure or frame over the bulkhead to aid material deployment, shown in Figure 3, whilst the use of rollers to pull the material directly on the grain stack was also considered (Figure 4). Each of the frame and roller designs were subsequently rejected, for example, due to the heavy weight that would have to be supported by the structure or the likelihood that wind could lift up the material.

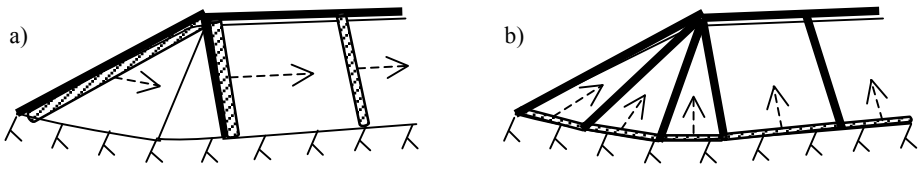

Figure 3 A fixed frame over the OBH. The frame in (a) has minimal supports and the material is pulled sideways; in (b) the material is pulled up the grain on either side of the stack.

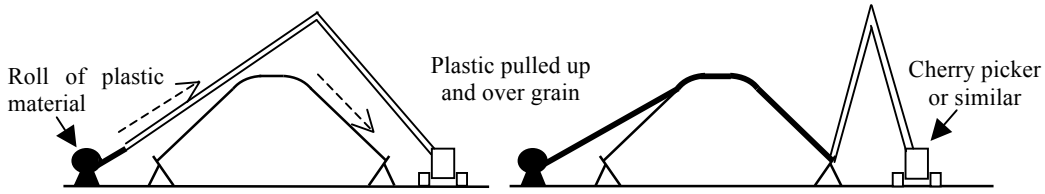

Figure 4 Sections of plastic deployed across the bulkhead from ground level.

The chosen deployment method involves the use of Hiabs and is being developed in-conjunction with the joining method. After exploring the use of heat shrinking or welding to bond adjacent edges, fixing them together with Velcro or tape or using a zip-lock seal, a joiner track system was settled on. This method uses lengths of rope fixed inside a pocket and a 'joiner track' element to deploy and join the material pieces. Similar to the way a sail is fed into the mast on a yacht, each rope and material section would be threaded into a c-shaped plastic extrusion. Two of these c-shapes, located back-to-back, form the joiner track.

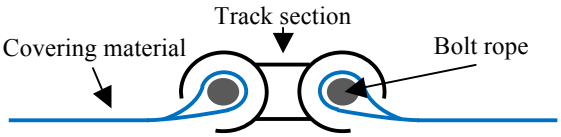

Figure 5 Profile of a joiner track, used to join two sections of material.

Once a section of material has been threaded into each side of the joiner track, a seal between those sections would be formed. The profile of the joiner track, as depicted above, has the c-shapes pointed slightly downwards in an attempt to make the join waterproof: when the material is pulled tight it should seal against the edge of the c-shape, blocking the path of water. Note that the profile that will be recommended to CBH is still being finalised.

3. Proposed Grain Covering Process

To summarise, the grain covering process will involve deploying lengths of Griffolyn T-90 onto the OBHs using joiner tracks. These joiner track sections will be laid on the grain and secured to the top of the bulkhead walls. The plastic material sheets will then be pulled off rolls at ground level and inserted into the joiner tracks. Each sheet will have a 90mm pipe slotted into a pre-fabricated pocket in its leading edge, and two c-shaped metal claws (similar to roller reefing claws used on yachts) will thread onto this pipe. Ropes will be attached to these claws and, with the aid of two Hiab's holding the ropes above the peak of the stack, the plastic sheet will be pulled over the grain.

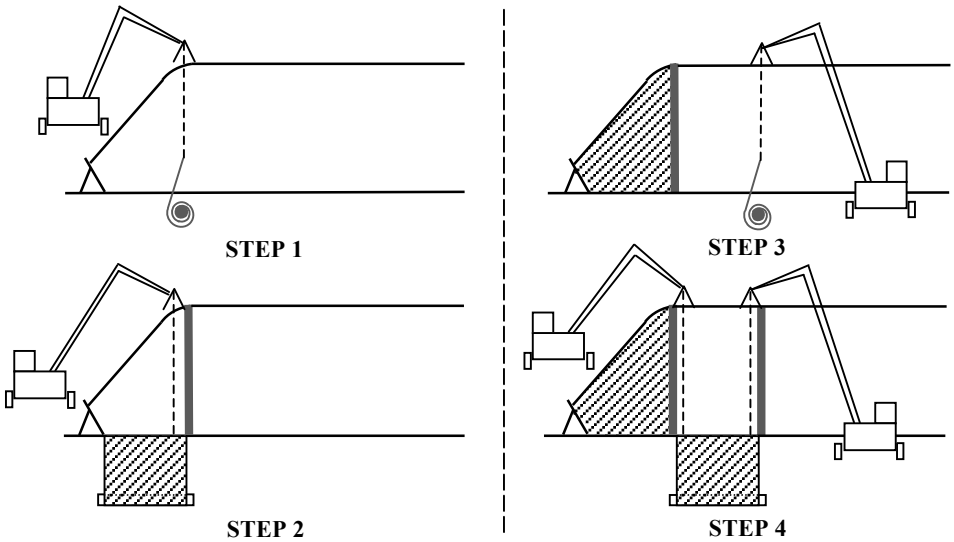

Figure 6 Schematic of the proposed grain covering process.

As shown in Figure 6, the grain stacks will be covered progressively and for the most part, two joiner tracks will be in place to aid the positioning of each section. For the starting and leading ends of the stack, however, only one joiner track is available. To deploy these sections, the inner side of each sheet will be pulled through the track as before, while the outer edge will be walked around the pile at ground level. Note that the plastic sections used to cover each end of the OBH will be of a different, fitted design that matches the shape of the stack. This means that whenever the leading end of the grain stack needs to be covered, this shaped end must be used. When the grain receival or outloading processes continue, this section will be removed and the 41x12m sections used until the end piece is required again.

The same technique will be used to seal the material to the edges of the bulkhead that is currently employed: each section of Griffolyn T-90 will be pulled tight and wrapped together with the Canvacon around a metal bar, which is clamped in place. When the OBH is only partially filled, weights will seal the leading section to the bitumen. To remove the material cover, the deployment process described will simply be carried out in reverse, and the material will be unthreaded directly onto the rolls, ready for re-deployment.

4. Conclusions and Future Work

The progress to date has involved developing the main concepts behind a new grain covering process that, when fully engineered, will allow OBHs to be properly covered without the need for workers to be on the grain stacks. The joiner track profile is still being developed; specifically the dimensions of the c-sections in relation to the bolt rope. A comparison between the proposed Griffolyn T-90 material and the PVC tarps is also underway and this will lead to a detailed cost breakdown of the new covering design.

Before the design recommendations compiled in this project can be implemented on OBHs in WA, each of the components will need to undergo detailed engineering design. Numerous prototypes and small-scale models will then be required to determine, for example, the optimal size and profile of the joiner track and diameter of the bolt rope to minimise friction without compromising the waterproof or impermeable qualities of the seam.

5. References

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