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Trial report

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# Post-consumer film recycling: Centriforce manufacturing trial



Report of panel product manufacturing trial at Centriforce Products Limited

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**Written by:** Richard W Curry and Liz Morrish



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**Front cover photography:** Recycled plastic panels at the Centriforce Products Ltd factory

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# Executive summary

This trial report forms part of a suite of reports demonstrating the technical feasibility of using fully comingled post-consumer film packaging to manufacture products that the retail sector can adopt for use within their store networks and as part of their product ranges for customers. The overall project involves a number of upstream recyclers and downstream manufacturers manufacturing a number of different products from post-consumer films. There are a number of individual trial reports available, in addition to a summary report for the whole project:

- Film separation at Biffa Waste Services Limited;
- Processing of LDPE film at Ecoplast;
- CeDo manufacturing trial;
- Agglomeration trial at Hanbury Recycling;
- Centriforce manufacturing trial;
- Protomax manufacturing trial; and
- Post-consumer film recycling (overall summary report).

A trial with Centriforce Products Limited, Liverpool was carried out to determine the feasibility of producing 12mm thick polyethylene panels from agglomerated UK post-consumer and retail film waste.

Feed material for the trial was collected from Sainsbury's front of store and back of store collections. It was sorted and agglomerated by Hanbury Recycling Ltd. Two levels of sort (thorough pick and minimal pick) were carried out, to produce two streams of feed material.

Each feed material produced panels that met Centriforce's requirements for dimensional conformity, flatness and impact resistance. Visual appearance, particularly with the product produced from minimal pick feed material, was somewhat inferior to its normal product but was judged to be acceptable for use as a hoarding material for example.

Both feed materials were handled satisfactorily by Centriforce's extrusion equipment although the frequency of screen changing was higher than that for its normal materials. The thorough pick feed material reduced screen life by about 50% and the minimal pick feed material reduced screen life by about 80%. This may require further investigation to ensure that a commercially viable recycling process is available.

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## Acknowledgements

Axion Consulting and WRAP would like to thank the staff at Centriforce Products Limited for their time and cooperation with this trial.

## 1.0 Background

WRAP has commissioned Axion Consulting to demonstrate the technical feasibility of using fully comingled post-consumer film packaging in economically and environmentally viable products. The project involves Axion working with a number of manufacturing companies to trial the production of products using post-consumer films.

The manufacturing trial partners and products being trialed are:

- CeDo: refuse sacks;
- Centriforce: rigid panels with a variety of end use applications including hoardings; and
- Protomax: rigid panels with a variety of end use applications including hoardings.

There is a suite of individual trial reports available, in addition to a summary report for the whole project:

- Film separation at Biffa Waste Services Limited;
- Processing of LDPE film at Ecoplast;
- CeDo manufacturing trial;
- Agglomeration trial at Hanbury Recycling;
- Centriforce manufacturing trial;
- Protomax manufacturing trial; and
- Post-consumer film recycling (overall summary report).

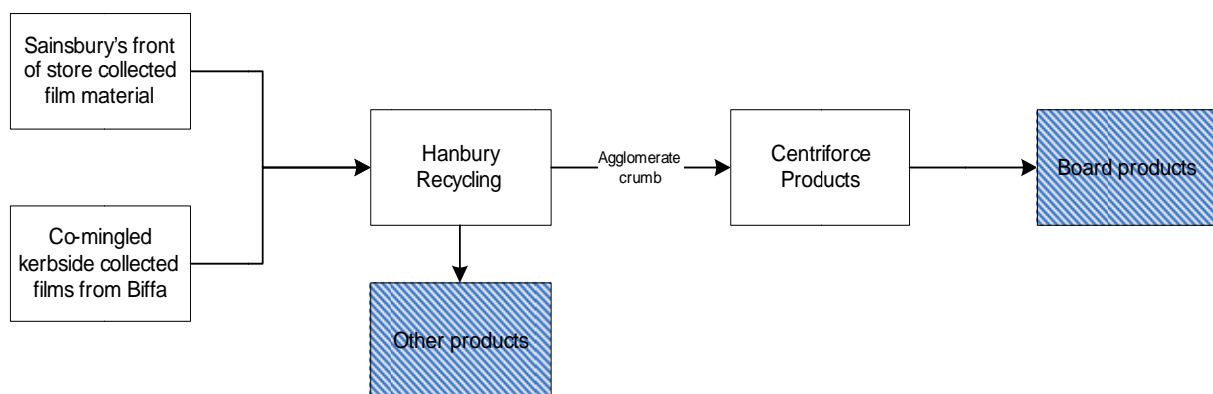
The trials are using two feedstock materials; plastic films collected through Sainsbury's front of store collection network and comingled films collected from domestic kerbside recycling schemes.

The manufacturing trial at Centriforce Products Limited was the final stage of this manufacturing trial. The first stage was a sorting and agglomeration trial at Hanbury Recycling to obtain crumb material for the manufacture of the Centriforce panels, which is covered in a separate trial report<sup>1</sup>.

The aim of this trial was to manufacture a number of panels using films from Sainsbury's. **Figure 1** shows an overview of the stages and companies involved in the Centriforce manufacturing trial.

The original plan for this trial was also to utilise post-consumer comingled film collected from domestic kerbside recycling schemes as a second feedstock source. It was not possible to do this due to Centriforce assessing the material and concluding the material was of too low quality to allow them to utilise it in its production.

**Figure 1** Centriforce trial overview



<sup>1</sup> WRAP MDP041 Post-consumer film recycling: Sorting and agglomeration trial at Hanbury Recycling – Trial report

## 2.0 Trial information

Trial host: Centriforce Products Limited Trial date: 9<sup>th</sup> March 2011

### 2.1 Description of trial host/equipment

The trial was conducted by Centriforce Products Ltd at its Liverpool factory on 9th March 2011. Centriforce is an established plastics processor, turning a range of plastic waste into rigid products. The principal materials it recycles are:

- Low density polyethylene (LDPE) sourced as bags, shrink wrap, packaging and supermarket waste;
- Medium density polyethylene (MDPE) sourced from utility piping;
- High density polyethylene (HDPE) sourced from bottles, crates, piping and film; and
- Polypropylene (PP) sourced from production waste, scrap sheets and crates.

Its product range includes:

- Protection products for underground cables;
- "Stokbord", a board which can be welded and fabricated into a variety of products for the agricultural industry, including animal pens, grain stores, troughs and ground protection mats;
- A range of profiles and planks used to manufacture a variety of products including fencing, picnic tables, benches, decking, boardwalks, street signs and vegetable boxes;
- Industrial grade sheets for fabrication purposes; and
- Industrial panels/boards, with white laminated film surfaces, that can be used as fence panels or security hoardings around construction sites as an alternative to plywood.

### 2.2 Objectives of the trial

The objectives of the trial were:

- To determine the feasibility of producing 12mm thick polyethylene (PE) panels from agglomerated UK post-consumer film waste; and
- Evaluate the panels to determine if they were of sufficient quality for Centriforce to consider them for use as security hoardings in its established markets for such products and potentially in other in-store retail applications.

### 2.3 Trial feed material

The waste material used for the manufacturing trial was a mixture of front of store (primarily carrier bags brought back to store by customers) and back of store (consisting primarily of shrink wrap and other large films) material collected by Sainsbury's. It was primarily PE film with some contamination by paper, other polymers and metals.

The material had been divided into two streams, each subjected to a different level of sorting/picking, at Hanbury's Recycling Ltd in Congleton, Cheshire<sup>2</sup>:

- A thorough pick, in which care had been taken to remove as much of the contaminants as possible; and
- A minimal pick, which was less thorough and removed only the largest items of contamination.

The minimal picking approach is considered by Centriforce to present a more commercially viable operation for sorting and agglomerating post-consumer film.

The resulting material batches were agglomerated at Hanbury's and then delivered to Centriforce at Liverpool in preparation for the manufacturing trial.

The delivered quantities were:

- Thorough pick – 1.580t; and
- Minimal pick – 1.680t.

Each batch of material was treated as a separate feed stream and was the subject of a specific trial. The panels produced from each trial were stored and evaluated separately from the other.

<sup>2</sup> WRAP MDP041 Post-consumer film recycling: Sorting and agglomeration trial at Hanbury Recycling – Trial report



The two materials are shown in **Figure 2** and **Figure 3**. The presence of larger particles of contaminant after the minimal pick is evident in **Figure 3**.

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**Figure 2** Agglomerated film material (thorough pick)



**Figure 3** Agglomerated film material (minimal pick)



## 2.4 Trial methodology

Each of the two feed materials (1.56t of thorough pick feed material and 1.68t of minimal pick material) was blended with 25kg of quicklime to ensure removal of any residual moisture from the agglomeration process. Centriforce would normally also include a black master batch to ensure consistent appearance of the final product. No master batch was used in the trial to ensure that the visual nature of the extruded waste would not be obscured.

The two blended feed materials were loaded into separate hoppers for feed into the extrusion line. The main components of the line are:

- A screw feeder, which converts the agglomerated particles into a molten and mobile material;
- A screen unit for removal of contaminant particles with higher melting points than the temperatures achieved in the screw feeder;
- A spreader for introducing the molten material into the roller mechanism in which the 12mm thick sheet is produced, with a white plastic laminating film applied to the top and bottom surfaces;
- A conveyor which allows the panel/sheet to cool;
- Trimming cutters which remove about 50mm of material from each edge of the panel/sheet; and
- A guillotine which cuts the panel/sheet to the sizes required for product panels, to remove sections of the sheet with major surface defects or to produce testing samples.

The thorough pick material was fed into the extrusion line first. As its hopper was becoming empty, the feed of minimal pick material was started. Thus there was a continuous feed of material into the extrusion line throughout the trial. The line was not stopped or purged at the transition between the two feed materials.

Centriforce recorded the time at which each feed material started to enter the extrusion line, the finishing time for the complete trial and the throughput rates. Panel products were stacked on pallets and weighed after the trial. Scrap material, whether as pre-start up purge, production scrap or edge trim, was collected separately and weighed after the trial.

## 2.5 Final product evaluation

The manufactured panel products were evaluated by:

- A visual examination of the white plastic film surface, as a qualitative comparison with Centriforce normal product quality;
- Measurement of each panel's length, width and thickness. The Centriforce standard for a cold panel is 2,440mm (+10/-0) long and 1,220mm (+6/0) wide. The trial panels were deliberately made slightly oversize to allow for trimming prior to any possible downstream trial applications. The intention was to produce warm panels of around 2,490mm by 1,245mm, with an expectation of 5-7mm shrinkage as the panel cooled. Centriforce regard a thickness between 11mm and 12.5mm to be acceptable;
- Visual assessment of the degree of upward curl along the edges. The Centriforce standard is that the outer edge should be no more than 10mm higher than the main flat section of the panel; and
- Impact testing using a Centriforce variant of a standard industry test.

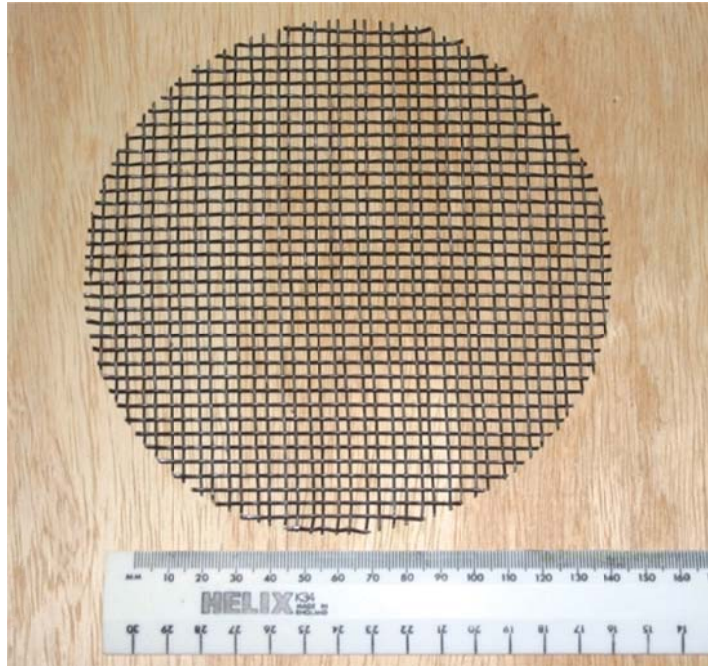


### 3.0 Results and discussion

#### 3.1 General observations

Centriforce was clear that the contamination levels in both feed materials were higher than in the waste materials it normally processes. This led to concerns over the likely performance of the screen unit; therefore it was decided to use the coarsest screen available, which was a metal mesh with an aperture size of around 5mm, as shown in **Figure 4**. Despite this, the screen life during the trial was much shorter than the 25-30 minutes found in normal production. Some contaminants did pass through the screen and led to visible surface and edge defects on the panels which, as discussed below, were more severe with the minimal pick feed material.

**Figure 4** Wire screen used for removal of high melting-point contaminants



#### 3.2 Thorough pick feed material

After addition of 25kg quicklime, the total feed material was 1.585t. From this, 27 panels were produced. The total weight of the panel products was 0.870t. The mass balance is shown in **Table 1**.

**Table 1** Mass balance on thorough pick material (t)

Material received from Hanbury's	1.560
Lime added by Centriforce	0.025
	-----
Total weight of feed material	1.585
Panels produced	0.870
Losses	
Pre-start up purge	0.100
Start-up scrap	0.315
Production scrap	0.150
Edge trim	0.120
	-----
Total weight after extrusion	1.555
Material unaccounted	0.030

The principal areas of material loss were:

- Pre-start up purge, where around 0.100t was used to remove traces of black master-batch and other residue of the previous production run;
- Scrap produced at start-up, where around 0.315t was lost establishing operating conditions in which the white film was applied without defects to the surfaces of the extruded material;
- Around 0.150t was lost during an attempt to reduce the degree of curl along the edges of finished panel. This involved an adjustment to the temperature of the extrusion rollers but led to loss of adhesion of the white surface film, illustrated in **Figure 5**. When the previous temperature regime was restored the adhesion problem was resolved;
- 0.120t was lost as edge trim; and
- 0.030t is not accounted for but is attributed to material left in the hopper that was removed by a vacuum cleaner at the end of the trial and not weighed.

The throughput rate for the trial was 0.417t/hr, which was slightly slower than normal production. However, due to the relatively small quantity of feed material available, Centriforce preferred to operate conservatively to be sure of producing panels of a sufficient quality for possible downstream trial applications.

**Figure 5** Air bubbles due to poor adhesion of white surface film



The results of the evaluation of the panels are shown in **Table 2**.

**Table 2** Evaluation of panels made from thorough pick feed material

Criteria	Centriforce standard	Trial panels	Comment
Length (mm)	2440-2450	2475-2492	Deliberately made oversize
Width (mm)	1220-1226	1235-1245	Deliberately made oversize
Thickness (mm)	11-12.5	11.7-11.9	Pass
Edge curl (mm)	Less than 10	Less than 10	Pass
Impact test	Cracks/tears within a 75mm diameter circle	Cracks/tears within a 75mm diameter circle	Pass

An example of a finished panel is shown in **Figure 6**.

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**Figure 6** Finished panel

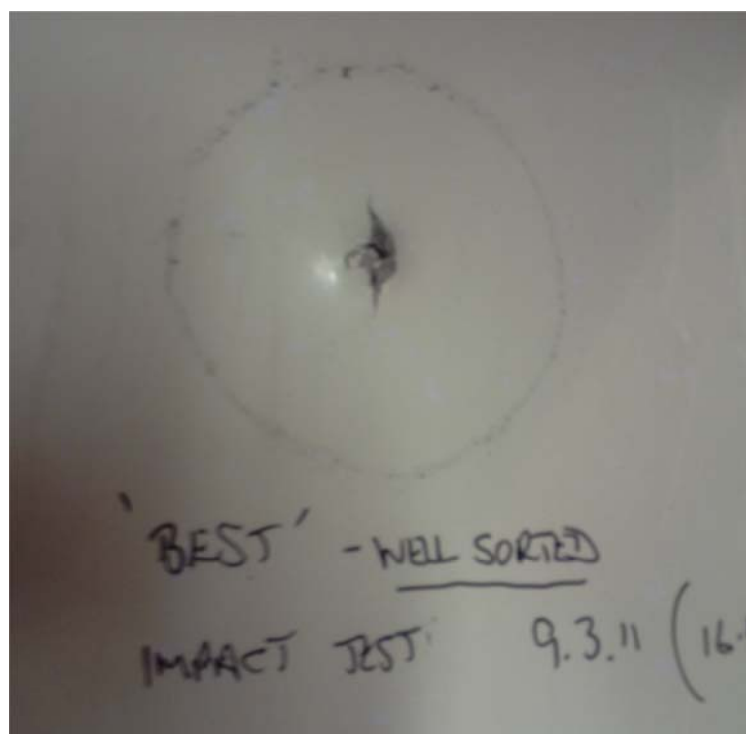


The finished panels met the planned oversize dimensions for length and width. Thickness was generally in the range 11.7-11.9mm, which is well within the range accepted by Centriforce. Panel flatness also met the specification of no more than 10mm of upward curl at the edges.

All test pieces passed the impact test. **Figure 7** illustrates the damage around the point of impact confined within a 75mm circle.

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**Figure 7** Results of impact test



The issues of concern were the consequences of contamination in the feed material for the operation of the screen unit and for product quality. Screens only lasted about 15 minutes before they needed to be changed as a result of becoming blinded by the contaminants. **Figure 8** shows a typical screen after removal from the machine, together with the thick layer of impurities that had built up during this short operating period. The particles of contaminant material can be clearly seen.

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**Figure 8** Fouled screen removed during extrusion of thorough pick feed material



Not all the contaminants in the feed material were removed by the screen. Those that passed through led to the following effects:

- Some surface irregularity was apparent where a contaminant particle was trapped between the surface of the extruded feed and the applied white film. This is illustrated in **Figure 9**;
- Some particles became sufficiently hot within the roller bank to cause occasional local punctures of the applied film, illustrated in **Figure 10**; and
- The presence of particles was clearly visible on the trimmed edges of the panels. Small voids were also visible in some places due, presumably, to particles having been dragged out by the trimming knives.

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**Figure 9** Surface irregularities due to trapped contaminant particles



**Figure 7** Puncture in white plastic film surface coating caused by hot contaminant particle in extruded material



Centriforce was clearly concerned about the manpower implications of frequent screen changes if it was processing this type of material on a regular basis. However, Centriforce judged the overall quality of the finished panels to be good enough to be offered for potential downstream use in for example hoarding applications.

### 3.3 Minimal pick feed material

After addition of 25kg quicklime, the total feed material was 1.705t. From this, 43 panels were produced. The total weight of panels was 1.460t. The higher level of product compared to the minimal pick feed material reflected the fact that a pre-start up purge was not necessary for this material and the conditions, which had led to start-up and production scrap were avoided during this production run. The mass balance is shown in **Table 3**.

**Table 3** Mass balance on minimal pick material (t)

Material received from Hanbury's	1.680
Lime added by Centriforce	0.025
	-----
Total weight of feed material	1.705
Panels produced	1.460
Losses	
Production scrap	0.060
Edge trim	0.170
	-----
Total weight after extrusion	1.690
Material unaccounted	0.020

The principal causes of material loss were:

- Production scrap of 0.060t;
- 0.170t was lost as edge trim; and
- 0.020t is not accounted for but is attributed to material left in the hopper that was removed by a vacuum cleaner at the end of the trial and not weighed.

The throughput rate for the trial was 0.373t/hr. This was below the rate achieved with the thorough pick feed material and appreciably slower than normal Centriforce production. However it was dictated by the increased frequency of screen cleaning, as discussed below, and the problems this raised for the stability of the molten feed material in the roller bank.

The results of the evaluation of the panels are shown in **Table 4**.

**Table 4** Evaluation of panels made from thorough pick feed material

Criteria	Centriforce standard	Trial panels	Comment
Length (mm)	2440-2450	2475-2492	Deliberately made oversize
Width (mm)	1220-1226	1235-1245	Deliberately made oversize
Thickness (mm)	11-12.5	11.1-11.5	Pass
Edge Curl (mm)	Less than 10	Less than 10	Pass
Impact test	Cracks/tears within a 75mm diameter circle	Cracks/tears within a 75mm diameter circle	Pass

An example of a finished panel is shown in **Figure 8**.

**Figure 8** Finished panel



The finished panels met the planned oversize dimensions for length and width. Thickness was generally reduced by about 0.5mm to 11.2-11.5mm compared to panels made from thorough pick material, again as a consequence of the stability of the material in the rolling bank, although still within the range Centriforce consider acceptable for a hoarding application for example. Panel flatness met the specification of no more than 10mm of upward curl at the edges.

All test pieces passed the impact test.



The issues of concern were with the contamination in the feed material. The impact on the operation of the screen unit and on product quality was more severe than with the thorough pick feed material. Screens lasted only about 6-7 minutes before they needed to be changed.

**Figure 9** shows a typical screen after removal from the machine. There was little visible difference to the screens with the thorough pick material but this condition was reached after the shorter operating period. The passage of contaminants past the screen led to similar effects to the thorough pick material although:

- The degree of surface irregularity from contaminant particles trapped between the surface of the extruded feed and the applied white film seemed more severe with the minimal pick material. This is illustrated in **Figure 10**; and
- The particles and voids on the trimmed edges of the panels were more clearly visible, as shown in **Figure 11**. The top panel was made from minimal pick feed material. The bottom panel was made from the thorough pick material. The difference in contaminant levels is evident.

Centriforce was more concerned about the manpower implications of frequent screen changes if it was processing this type of material on a regular basis. However Centriforce judged the overall quality of the finished panels to be good enough to be offered for potential downstream use in hoarding applications for example.

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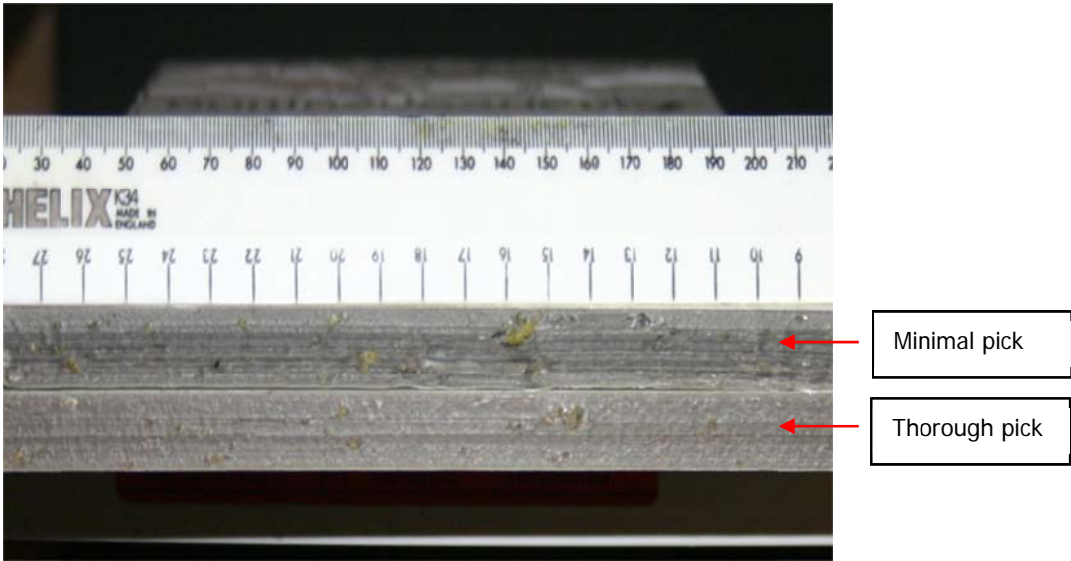
**Figure 9** Fouled screens removed during extrusion of minimal pick feed material



Figure 10 Surface irregularities due to trapped contaminant particles



Figure 11 Comparison of voids and particles visible at edge of panels



## 4.0 Conclusions and recommendations

The key conclusions from the Centriforce manufacturing trial are:

- A total of 70 panels were produced (27 panels from the thorough pick material and 43 panels from the minimal pick material);
- Both feed materials (thorough and minimal pick) produced panels that met Centriforce standards for dimensions, edge curl, and impact resistance;
- The level of high melting point contaminants led to rapid blinding of the screens. With the thorough pick material, screen life was around 50% of Centriforce normal production performance. With the minimal pick material, screen life was reduced to less than 25% of normal production performance; and
- High melting-point contaminants passing the screen led to an incidence of surface irregularities that was higher than the normal Centriforce product but was judged to be acceptable for a hoarding application for example. The irregularities were more noticeable with the minimal pick feed material than with thorough pick material.

The key recommendations from the trial are:

- Despite the effect of the high melting-point contaminants on surface appearance, Centriforce judged that the panels were of sufficient quality to be used in a hoarding or similar application relevant to a retail environment. It is therefore recommended that products from this trial be put forward to a prospective user for evaluation; and
- The issue of screen changing should be investigated further to determine whether the frequency found necessary during the trial is too high for a commercially viable process and, if so, whether an automatic screen changer or a continuous screen cleaner would be appropriate. Centriforce believe that improved technology is certainly a possibility, with a laser filter being one particular option to consider further. The key issue will be the opportunity this provides versus the cost of investing in new technology.

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