



Application for Novel Technology Status for CleanStream®

General

CleanStream® is the registered trademark for a proprietary integrated recycling process technology developed by Plasgran Limited, with registered Offices at Unit B&C, Ashbourne Drive, Leamington Spa, CV31 3SF, United Kingdom, a wholly owned subsidiary of Amcor PLC.

The primary CleanStream® installation is located at;

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United Kingdom

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Executive Summary

CleanStream® is a complete recycling process (**Figure 1**) which takes in kerb-side recovered waste PP. Polypropylene is a hydrocarbon, semi-crystalline polymer. Compared to PET it has higher diffusivity, therefore is more likely to acquire residual NIAS through use. This higher level of diffusivity also means that it is more efficient to drive the removal of VOC and SVOC compounds using a solid-state decontamination process, [REDACTED] utilised in the CleanStream® process. The process is further enhanced by bespoke selective sortation, which removes coloured and non-food-use items, ensuring that intentionally added substances (such as additives and pigments) are limited to those suitable for food-use applications. High temperature chemical washing removes surface contamination and decoration to limit the potential for the breakdown of organic inks and binders into substances of concern.

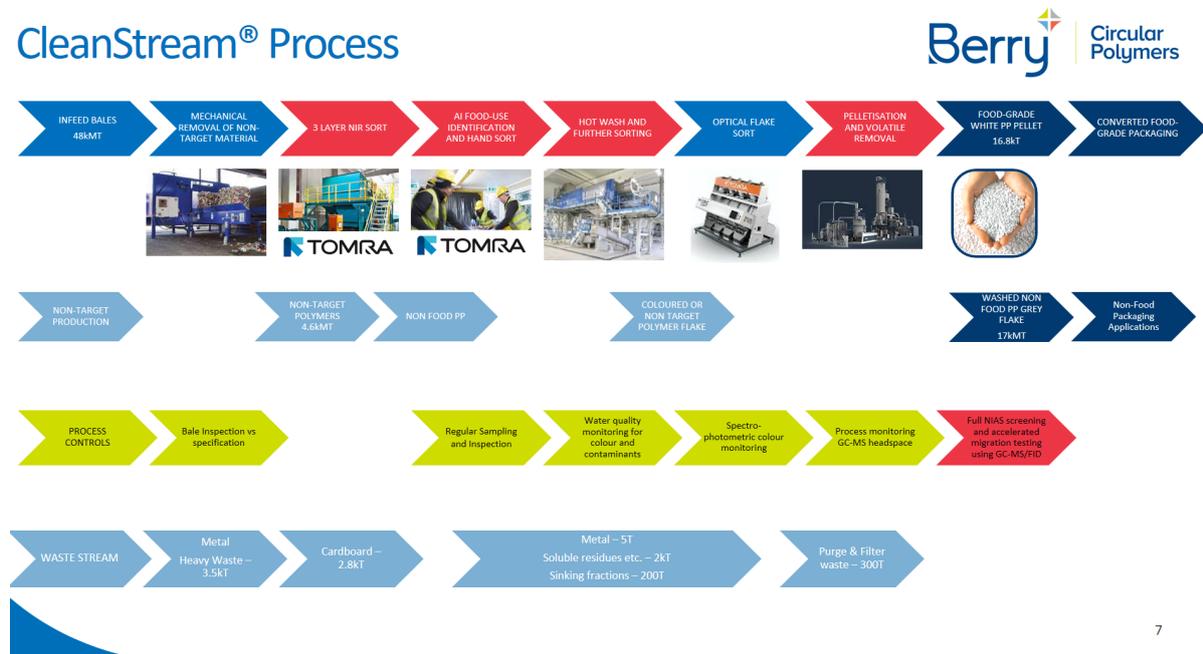


Figure 1. A basic flowchart of the process' stage including the step objective, what the step removes and the key control parameters relevant to the step (A higher resolution version can be found in appendix 2).

The incoming material is subject to **several integrated decontamination steps** and as such **all these together form the basis of the Novel Technology Application** – individual steps would not on their own constitute a recycling technology covered by this application;

- An extensive sorting process, *including the AI assisted identification of food use items* to ensure input streams are compliant with EU regulation 10/2011
- A Caustic hot wash at [REDACTED] followed by a freshwater rinse and drying stage
- A further flake sort process
- A pre-extrusion and melt-phase de-volatilisation process
- Underwater pelletisation
- Solid-state volatile and semi-volatile removal process



The primary feed to the process is mixed colour short life polypropylene post-consumer pots, tubs and trays (PTT) which have been pre-sorted at a MRF or PRF. From this feedstock, the white and clear non-bottle fraction is isolated and is defined as the input for the food grade production.

The isolation process consists of 3 layers of automatic sorting, the final stage being an AI backed object recognition stage capable of providing an infeed which is >95% food use packaging in their last application. This is followed by a hand sort to verify and ensure compliance.

This fraction is chosen for the following reasons:

- White and Natural items have low printing ink levels and any remaining inks which are present after washing are easy to see and remove.
- White and Natural materials do not contain compounded organic pigments that have a potential for decomposition.
- Bottles make up the largest percentage of non-food items in the PP Pots, Tub and Trays ('PTT') stream. In addition, bottles have a higher potential for misuse than trays so removing them reduces the risk of hazardous contamination.

This fraction is washed free of physical contamination, and a chemical wash removes printing inks. A density separation stage removes any PP with a density above 1g/cm^3 and so removes any filled PP with greater than 10% filler.

The washed flake is optically sorted, on both sides, to remove any coloured polymer and flakes that still have a material amount of printing ink on them. Any Print system remaining will be less than 400ppm.

This flake is at least 99% polymer that meets food contact requirements of EU Regulation 10/2011 and, in excess of, 95% PP which was in direct food contact on its last use cycle. This can be demonstrated as even in non-food contact applications for single use packaging >90% of polymer used is virgin polymer which meets the EU regulation 10/2011 regulation.

This flake is processed in an [REDACTED] that degasses, filters and super-cleans the PP. This process has been challenged tested by Erema and decontamination efficiencies are shown later in this document.

All output material will be screened on a batch release basis using on-site analytical techniques, including XRF and GC-MS/GC-FID, for NIAS and specific contaminants (PAH/Phthalates/Heavy Metals) according to customer specific requirements and to demonstrate compliance to applicable packaging regulations.

The process utilises washing and de-volatilisation steps already proven effective in other polymer recycling processes for PET and combines this with state-of-the-art selection and recognition technologies that ensure ultra-high levels of purity through the washing process.



Glossary

AI: Artificial Intelligence

BRP: Batch Release Protocol

COD: Chemical Oxygen Demand

EPR: Extended Producer Responsibility

FCM: Food Contact Material

FID: Flame Ionisation Detection

GC: Gas Chromatography

GRN: Good Received Number

HDPE: High Density Polyethylene

IML: In-Mould Label

MFI: Melt-Flow Index

MRF: Materials Recycling Facility

MS: Mass Spectrometry

NIAS: Non-Intentionally Added Substances

NIR: Near Infra-Red

OM: Overall Migration

PAH: Polycyclic Aromatic Hydrocarbons

PCU: Pre-conditioning Unit

PET: Polyethylene Terephthalate

PO: Polyolefin (PP and PE)

PP: Polypropylene

PRF: Plastics Recycling Facility

PRN: Packaging Recovery Note

PTT: Pots, Tubs and Trays

QC: Quality Control

rPP / rHDPE: Recycled PP / Recycled HDPE

SVOC: Semi-volatile Organic Compounds

SML: Specific Migration Limit

SCADA: Supervisory Control and Data Acquisition

UWF: Unwashed flakes

VOC: Volatile Organic Compounds

Process Description

Figure 2 shows the main manufacturing stages, and quality control points carried out at the recycling facility. All quality data will be kept in physical and electronic form, backed up via multiply redundant cloud-based systems, in line with the business' IT strategy.

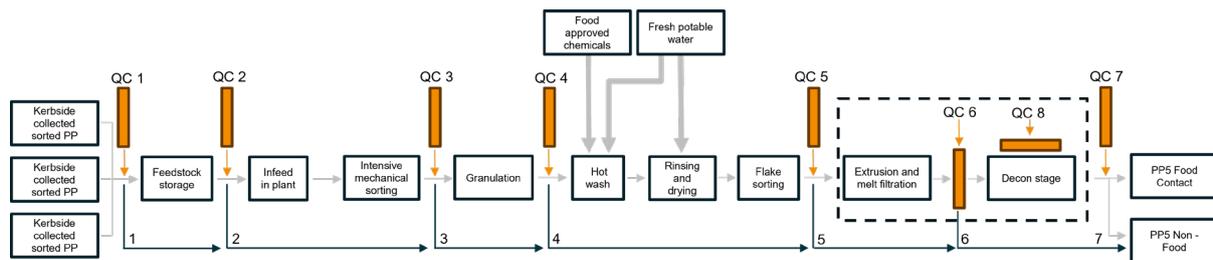


Figure 2. Diagram of the main manufacturing stages carried out at the recycling facility (site diagram).

1. Delivery

Step Objective: Delivery Inspection to ensure bale input quality is in line with agreed contractual and commercial standards. Record keeping protocols in line with EA permitting to demonstrate waste packaging content for EPR/PRN purposes.

Amcor purchases sorted baled PP from third parties. The supply chain comes from domestically collected post-consumer packaging and it must be a single stream post-consumer polypropylene. This means that the PP has already been sorted to reach the purity we agree with our suppliers. At each level of sortation, prior to reaching our facility there are quality checks both in and out monitoring contamination levels.

Before any new supplier is engaged a pre-acceptance site visit is undertaken to ensure the material will be of suitable quality to meet the expectations of our process. Checks carried out ensure the feedstock is from household collections and the process, sortation and quality procedures meet expectations.

All suppliers will be audited by Amcor and pre-approved for supply. This audit is documented within the Quality system. This audit will ensure that suppliers can control the levels of contamination in the bales they supply. For ongoing suppliers there is an annual onsite audit as a minimum. A sampling procedure for all incoming material is in place. A new supplier is sampled for every load supplied for 8 weeks to ensure the quality of the material is as agreed. Following these eight weeks the sampling procedure is a minimum of 1 load in 5. Checks are for all contamination but also for compositional analysis of food contact material and colour.

1

Non Conformance Reporting procedure :

Step 1.

Shift Manager will need to complete the Complete Non Conformance Report detailing all requested information within the document with photographic evidence highlighting the material of concern, the information provided will be key when discussing with 3rd party suppliers so the more information provided the better.

This will need to be emailed to myself and Rosie Barber.

Step 2.

2x 20kg Samples from Random bales that remain from the load will need to be collected for further analysis to understand the quality of the material, we are aware that a 20Kg sample does not represent the load in its entirety but this gives further demonstration to the 3rd party that we are doing everything in our power to reduce contamination coming through the process at Leamington spa.

Step 3.

The PO information, time and date of 3rd party in question will then be emailed to Sophie Lowrey, we will need to get the information from the Grey Parrot to review any spikes in non-target material and what this was, this further enhances our position when reporting this to 3rd party suppliers.

Supplier Non-Conformance **2**

Part 1 - Initial Details			
Quantity Log Reference	Date Delivered		
Date Raised	Expected Material		
Raised by	Concern Type (i/Weight)		
Customer Name	Weight Affected (KG)		
Number of Bales	Purchase Order No. PPO		
Gross Weight (KG)	Net Weight (KG)		
Description of Concern			
Immediate Remedial			
Action Items	Person(s) Responsible	Deadline	Done?
Please ensure that any photos/documents are saved and uploaded to Good Reuse			
PARTS 2 AND 3 - TO BE COMPLETE BY EXTERNAL SUPPLIER (CUSTOMER) AND RETURNED TO BERRY CIRCULAR POLYMERS WITHIN 72 HOURS OF RECEIPT.			
Part 2 - Investigative Action			
Issued To:			
Investigations Carried Out:			
Conclusion:			
Supplier Follow Up			
Action Items	Person(s) Responsible	Deadline	Done?
Photos			
Berry Circular Polymers - Photos embedded			

Figure 3. reporting procedure and form for a non-conforming load of input material.

The baled polymer arrives on a time allocated delivery schedule to site and is booked in at the weighbridge. All the paperwork for the delivery is checked before the load is allowed to enter site and failure to supply will cause rejection of the load. All loads are controlled on site by the purchase order number which is checked according to the schedule and allocated a bay for offloading.

QC1 - Visual inspection on arrival (Technical document LS-EHS-SSW-137): The loads received will be visually inspected and photographed to establish the correct material has been sent and is safe to unload *i.e.* no risk of bales falling. Any concerns regarding load material quality and safety will be escalated to site management and the commercial team.

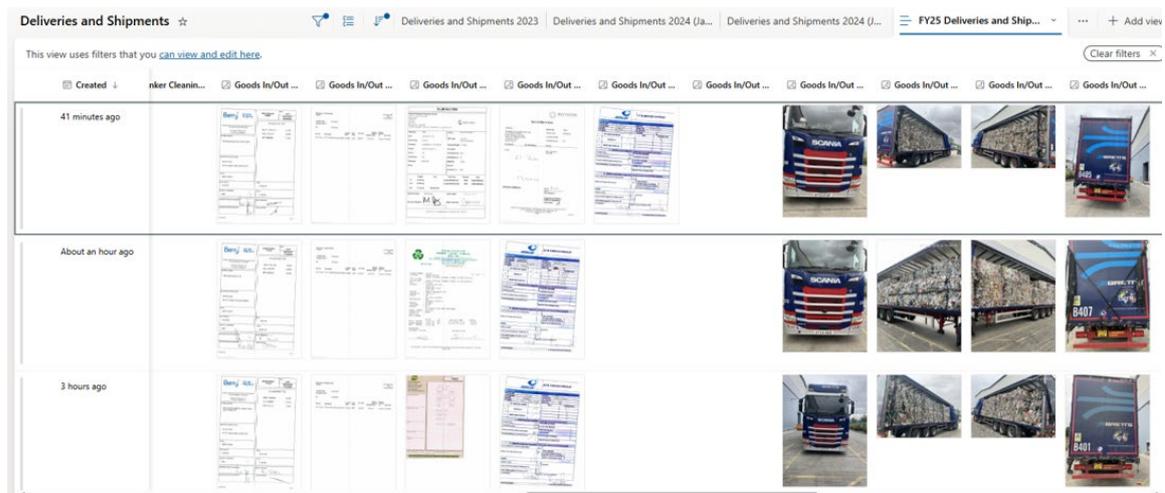


Figure 4. Example of the loading documents and pictures that are collected, chosen at random.

Once the bales are offloaded, they will be stored in allocated bays for tracking and given quarantine status until QC testing has been completed. A temperature testing gun will be used to make sure that the temperature of the bail is <50°C, or within 15°C of ambient temperature. If the load does not comply, it will be moved to the quarantine area until its temperature has reduced. Once the material is tested and conforms to our specification it is then passed to enable picking and loading into the plant. All quality data, including pictures (**Figure 4**) is stored on the Quality management system to be reviewed at any time to generate reports and trends.

2. Infeed

Step Objective: The material is moved from the feedstock storage area to the sorting plant. The bales are broken to deliver a smooth controlled flow of singularised plastic items. After sorting a sample of the material is taken to ensure that it is >95% former food contact PP.

QC2 – Sampling and testing feedstock (Technical document SOP023): In house developed process to ensure that the quality of materials fed into the plant is tested regularly to ensure commercial and PRN standards are maintained.

For a minimum of every 5 loads *per* supplier, 1 bale needs to be sampled. A bin containing 20kg ± 1kg of sample, is photographed and the different polymers and other typed of contamination (glass, metals, wood, etc) are separated, with the aid of a NIR gun. The different components of the sample are then weighed and recorded ensuring an accurate mass balance.

3. Sort

Step Objective: the infeed is passed through several layers of mechanical and AI-assisted sorting to ensure that the input streams are compliant with EU regulation 10/2011.

Metal Extraction: Remove as much metal as possible while limiting the loss of plastics.

Metal needs to be extracted as soon as possible so that it does not damage equipment.

There are three types of metal found in bales plastic especially PTT type material.

- a) Free metal (ferrous and non-ferrous) such as cans, coat hangers, baler wire
- b) Trapped metal, for example in dispensing closures
- c) Metal foils such as crisp packets

The material passes through several stages of over-band magnets, head roller magnets and eddy current separation which is effective at removing most of type a) and some of type b).

When the weight of plastic containing the metal is too large (such as a pump dispenser) then the plastic and metal will pass through. These will be removed later, either at the object recognition section or in one of the 3 float/sink sections after size reduction.

Dry Trommel: Removes material that is too small for effective sortation.

Ballistic Separation: Remove 2D materials that cannot be effectively sorted.

NIR/Colour Sorting and Object Recognition: Non-target polymers (mainly PET and HDPE, non-food grade polymer, and coloured PP) are removed.

The aim of this step is to isolate white/natural PP at very high purity levels. The target material passes through 3 layers of sorting according to the logic below:

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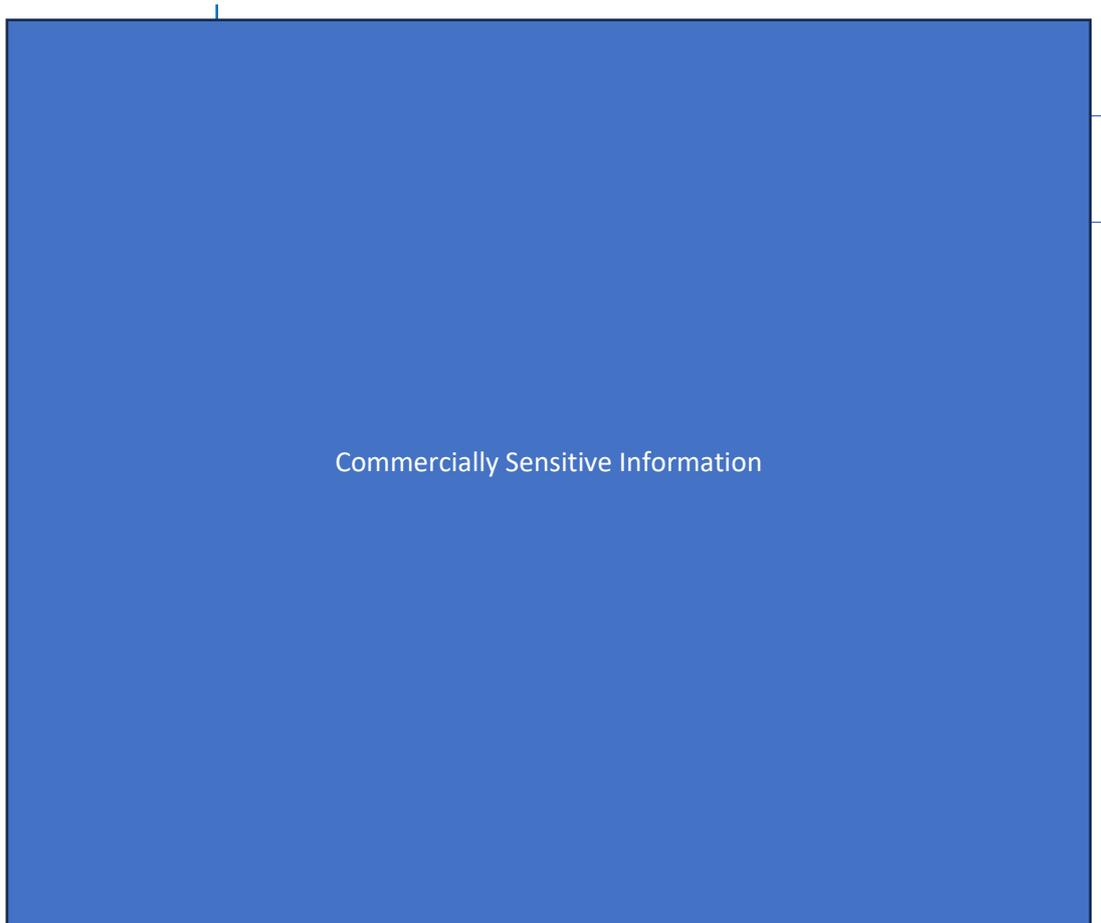


Figure 5. schematic representation of the 3 layers of sorting.

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All bottles will be targeted for removal, regardless of whether they are food use items or not.

Misuse and specifications of the pre-processed input

PP misuse is where non-food products are stored in bottles and the bottles put into the recycling stream. Materials of concern would include pesticides, herbicides, oils and paint strippers. The advantage of removing bottles is that such material is unlikely to be stored in PTT.

The assessment by the European Food Standards Agency (“EFSA”) looked at misuse in their evaluation of rHDPE and concluded as follows:

Following the same approach used for the evaluation of recycled PET, the CEF Panel considered that the highest potentially misuse contamination level in washed and dried HDPE flakes was 6,500mg/kg HDPE (based on a concentration of 130mg/kg measured for 50 flakes) and that 2 out of every 24,000 bottles were contaminated with misuse contaminants (0.008%), giving a reference contamination level of 0.5mg/kg HDPE.

Since the maximum level of bottles in the stream is 5% then, applying the same conservative logic, the potential contamination for misuse is 25ppb. This value is already close to the limiting level of concern (10ppb) even before the super-cleaning extrusion.

Due to the specific nature of the input stream at this stage of the process (already >99% white, natural and PP only) *non-food items are limited to a narrow range of applications* (predominantly gel capsule boxes for washing detergent, **Figure 6**) and as such are easily identified by the AI.

As a result of the AI Learning ability, if the composition of the waste stream changes, examples of any “new” non-target materials can be kept, then captured and uploaded into the neural network to update the non-target database.



Figure 6. Gel Capsule Containers

QC3 - FDA sampling and testing (Technical document SOP080): in house process developed to ensure that final material complies to FDA standards and are maintained.

Two bin bags of samples are collected from the picking cabin conveyor belt. These are then separated into food and non-food items. The percentage of food contact PP is then calculated from the weighed fraction. A passing lot needs to be >95% food contact PP. All the data is recorded (**Figure 7**).

<p>1</p> <p>Operational... > Material Qu...</p> <p>PPO48759</p> <p>Purchase order number * PPO48759</p> <p>SITE of Sampling Leamington Spa</p> <p>MATERIAL TYPE PP Bales (Feedstock)</p> <p>Supplier</p> <p>Comments Enter value here</p> <p>Date of Sample * 14/07/2025</p> <p>Month (Read only) 14/07/2025</p> <p>Sample WASHED? * NO</p> <p>1. Polypropylene Natural (FOOD)* KG * 8.80</p> <p>2. Polypropylene White (FOOD)* KG * 6.80000</p> <p>3. Polypropylene Natural & WHITE (NON FOOD)* KG * 0.70</p>	<p>2</p> <p>5. Polypropylene Jazz (NON FOOD/ALL)* KG * 3.40</p> <p>6. PET Jazz* KG * 0.00</p> <p>7. PET Clear* KG * 0.10000</p> <p>8. HDPE Natural* KG * 0.00</p> <p>9. HDPE Jazz* KG * 0.00000</p> <p>10. PE Film KG 0.20</p> <p>11. Hard Plastics (PE, PP or PET) KG 0.30</p> <p>12. Black Plastics (PE, PP or PET) KG 0.30</p> <p>13. Plastic FINES KG 0.00</p> <p>14. Textiles (PE, PP and PET - Polymer Based) KG 0.00</p> <p>15. Aluminium Cans KG 0.00000</p> <p>16. Steel Cans KG 0.00</p> <p>17. Paper & Cardboard 0.00</p>	<p>3</p> <p>18. Paper Labels KG 0.00</p> <p>19. Tetrapak / Multi Material Packaging KG 0.00</p> <p>20. Glass KG 0.00</p> <p>21. PVC & PMMA KG 0.00</p> <p>22. HIPS KG 0.00</p> <p>23. Polystyrene KG 0.00</p> <p>24. Textiles (Cotton/Non Polymer Based) KG 0.00</p> <p>25. HOUSEHOLD WASTE* KG * 0.04000</p> <p>1A. Polypropylene Natural (FOOD) % (Read only) 42.64%</p> <p>2A. Polypropylene White (FOOD) % (Read only) 32.95%</p> <p>3A. Polypropylene Natural & White (NON FOOD) % (Read only) 3.39%</p> <p>4A. Polypropylene Jazz % (Read only) 15.47%</p> <p>6A. PET Jazz % (Read only) 0.00%</p>	<p>4</p> <p>7A. PET Clear % (Read only) 0.48%</p> <p>8A. HDPE Natural % (Read only) 0.00%</p> <p>9A. HDPE Colour % (Read only) 0.00%</p> <p>TOTAL WEIGHT SAMPLED KG (Read only) 20.640</p> <p>TOTAL PP KG (Read only) 19.70</p> <p>TOTAL PET AND HDPE PACKAGING KG (Read only) 0.10</p> <p>TOTAL POLYMER NON PACKAGING (Read only) 0.80</p> <p>TOTAL NON POLYMER RECYCLATE KG (Read only) 0.00</p> <p>TOTAL WASTE / NON ACCEPT KG (Read only) 0.04</p> <p>TOTAL PP % (Read only) 95.446%</p> <p>TOTAL PET AND HDPE PACKAGING % (Read only) 0.48%</p> <p>TOTAL POLYMER NON PACKAGING % (Read only) 3.88%</p> <p>TOTAL NON POLYMER RECYCLATE % (Read only) 0.00%</p>	<p>5</p> <p>TOTAL WASTE / NON ACCEPT % (Read only) 0.194%</p> <p>Photo 1 PP Weight NAT&WHT FOOD</p> <p>Photo 2 PP NAT&WHT NON FOOD</p> <p>Photo 3 PP Jazz Total (Non food & Food)</p> <p>Photo 4 PET Weight</p> <p>Photo 5 HDPE Weight Add an image</p> <p>Photo 6 WASTE Weight</p> <p>Photo 7 Hard Plastics Weight Add an image</p> <p>Photo 8 Plastic Film</p> <p>Sample Photos Taken? ✓</p> <p>TOTAL NON PACKAGING, NON POLYMER AND WASTE (Read only) 4.07%</p> <p>CHECK (Read only) 100%</p>
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Figure 7. Example of a data sheet for the food sampling and testing (cropped to fit it all in one image).

4. Shred/Wash

Step Objective: The material is shredded, hot-washed, and rinsed to further reduce the contamination level.

Wet granulation: A wet granulator preceded by a coarse shredder, protected by a coarse sink float will granulate and wash the material via a 20mm screen. This is done to reduce particle size to 20mm, regrind, and remove all dirt, paper, wood, heavy polymers. After granulation the material flows is dewatered via a friction centrifuge drier and stored in an interim silo prior to the hot wash.

QC4 – Input flake testing (Technical document, SOP001, SOP004, SOP024, SOP055): the Unwashed Flakes (UWF) are analysed through different analytical techniques.

Samples will be taken directly from the feed silo at the input to the washing section, in flake form. All samples will be stored for a minimum of 24 months.

Specific Migration will be carried out on the flakes using a [REDACTED] solution [REDACTED] V/V. 2g of flakes, in 20mL of the solution, will be kept at [REDACTED]. 10mL of that solution will then be concentrated by a factor of 10, using a rapid evaporation system. The resulting extract is spiked with the appropriate internal standards prior to liquid injection GC-MS and GC-FID analysis.

GC-MS characterisation for VOC screening will be carried out by headspace analysis using vial pressurisation and sampling loop method. Sampling will be carried out after incubation at elevated temperature.

See **Decontamination efficiency from flakes to pellets** for a more detailed analysis of the flake contamination, with comparison with the final product.

Caustic wash: A caustic hot wash [REDACTED] will remove most surface decoration (IML and direct print) and any residual surface contamination (*All water supplied to the hot washing line will be directly from*



potable mains supply. The wastewater is treated via a biological and chemical water treatment plant and recycled for use in the wash plant for non-food items only).

Density Separation and rinse: The cleaned flake will pass to the final washing section, which comprises a freshwater rinse and float/sink followed by a centrifuge dewatering, and hot air-drying section. This section removes any residual contaminants from the surface of the polymer, including remaining chemicals from the hot wash phase. Air classification (elutriation) removes remaining films, fines and label residues to provide a consistent, particle-size controlled input to the final sorting phase which is carried out on the washed flake material.

A flake buffer, before the separation step, allows operation as a consistent feed point for the separation and a control point back to the granulator feed. A buffer silo ensures an even feed to the flake sorting section.

5. Flake sorting

Step Objectives: ensure that >99% white or natural PP flakes pass to the next stage.

Double sided NIR detecting optical sorters will ensure that any remaining printed or coloured flake is removed along with any remaining non-target polymer contamination. Purity levels of white/natural PP are >99%. Removal of even lightly coloured flakes will ensure that printing inks are minimised into the extrusion stage.

A dedicated interim blending silo for storage of the washed flake is installed after the flake sorting step.

A pneumatic conveying system discharges the material directly into the PCU of the Erema compounding line.

Following the guidance that can be found in section 5.1.1.3 of *“Scientific Guidance on the criteria for the evaluation and on the preparation of applications for the safety assessment of post-consumer mechanical PET recycling processes intended to be used for manufacture of materials and articles in contact with food (EFSA, 2024)”*, the values of interest for our input stream are:

- Flake dimensions
- Bulk density
- Plastics other than PP, e.g. PET, PVC, Styrenics, polyamide, polycarbonate (considering potential degradation during recycling and further processing)
- Glue
- Other specification parameters, e.g. dust, moisture, metal, cellulose, if considered relevant for the proper functioning of the processes

The following tests will be carried out after the washing plant. The first test will be an inspection of the flakes (Technical document SOP073) checking for:

- Evidence of print
- Smell
- Grease or oily residue
- Presence of film
- Coloured flake

The bulk density is measured (Technical document SOP061) by filling a 100cm³ beaker with the washed flakes and weighing it. The bulk density can be obtained from:

Bulk density = Mass of the sample (g) / Volume of container (cm³)

The sinking fraction in the sorted flakes will be measured (Technical document SOP074).

QC5 - Wash water quality assessment (Technical document SOP013): The Chemical Oxygen Demand (COD) of the flake samples will be determined following the in-house method developed from USEPA1 Reactor Digestion Method2.

This method allows us to determine the residual contamination on surface of flakes. This method is as follows: a given quantity of the sample is mixed with a measured volume of sodium hydroxide. The

organic residue found present on the surface of the flakes produces an increase of the COD level, which can be measured through a colorimetric analysis.

A COD >100mg/L will be classified as advisory, and the root cause will be investigated. All results are logged in a spreadsheet (**Figure 8**).

1	Shift	Date	0.1N HCL (ml)	Alkalinity	Analyst	EC (mS/cm)	EC Min	EC Max	EC Target	COD	COD Min
269	Day	7/9/2025	37.5	28.5	RS	20.7	20	50	●	63,340	8,000
270	Night	7/10/2025	43.0	32.7	EC	51.8	20	50	●	28,300	8,000
271	Day	7/11/2025	27.0	20.5	rh	29.8	20	50	●	30,201	8,000
272	Day	7/12/2025	32.5	21.0	RH	33.4	20	50	●	14,265	8,000
273	Day	7/21/2025	27.7	38.1	KK	35.9	20	50	●	23,100	8,000
274	Day	7/22/2025	30.3	34.8	UK	28.7	20	50	●	15,700	8,000
275	Day	7/23/2025	19.3	14.7	VC	27.6	20	50	●	15,650	8,000
276	Day	7/24/2025	24.8	18.8	VC	28.6	20	50	●	15,100	8,000
277	Day	7/25/2025	27.2	20.7	AK	29.2	20	50	●	13,600	8,000
278	Day	7/26/2025	25.0	19.0	RS	27.1	20	50	●	21,350	8,000
279	Day	7/27/2025	24.7	18.8	KK	25.5	20	50	●	29,249	8,000

Min	COD Max	COD Target	Non-Ionic (mg/L)	RP34 (mg/L)	RP34 Target	Analyst2	Comments
8,000	16,000	●	1,620	826	●	RS	EC AQC 425, CWx10, COD AQC 104, Ionic AQC 0.709 AQC
8,000	16,000	●	1,015	518	●	EC	EC AQC 428, CW x50, COD AQC 105, Ionic AQC 1.81
8,000	16,000	●	987	503	●	RH	
8,000	16,000	●	620	316	●	RH	
8,000	16,000	●	1,685	859	●	SLB	
8,000	16,000	●	2,095	1,068	●	UK	
8,000	16,000	●	640	326	●	EC	EC AQC, CW x50, COD AQC 103, Ionic AQC 1.90
8,000	16,000	●	138	70	●	EC	EC AQC, CW x50, COD AQC, Ionic AQC 1.90
8,000	16,000	●	582	297	●	AK	
8,000	16,000	●	1,210	617	●	RS	EC AQC 382, CW x50, COD AQC 195, Ionic AQC 1.97
8,000	16,000	●	925	472	●	KK	

Figure 8. Example of the COD analysis on flakes (cropped into two lines to make it more legible).

6. Extrusion and Decontamination

Step Objective: re-melting, filtering, devolatilizing, pelletising and refreshing the polymer.

Extrusion and melt filtration: Compound, filter and remove un-meltable polymers, metal, wood, migrating compounds. The [redacted] pelletising line is fitted with a [redacted] Laser-cut filter screen pack and benefits from a 3-stage volatile and semi-volatile decontamination process;

- Initially in the PCU the flaked material is heated to >100°C and held for approximately 1hr, with Air-Flush technology driving off volatile species within the material before the melt processing stage
- Processing temperatures of >180°C and melt pressures >5bar ensure complete microbial sterilisation of the polymer melt
- A triple-degassing melt-phase volatile removal system at 0.5bar minimum vacuum and >190°C

An underwater pelletiser is fitted for optimum pellet quality.

QC6 – Testing of colour before refresher (Technical document SOP030): In-house developed method to determine the colour, transmittance and gloss of the polymer samples.

A Konica Minolta spectrophotometer CM-36dG or equivalent will be used to determine the colour of plaque of rPP material (**Figure 9**). These plaques have been produced *via* injection moulding of pellets, prior to the refreshing process. The ΔE value to a standard target must be <2.5 to constitute a pass. If it fails, the material will be directly sent to bags, and the output will be classified as non-conformance until the right conditions are met.

	Data Name	Data Comment	Timestamp	Group Traits	Target No.	Data Number	Judgement	L'(D65)	a'(D65)	b'(D65)	C'(D65)	h(D65)	dL'(D65)	da'(D65)	db'(D65)	dc'(D65)	dH'(D65)	dE000(D65)	dE'ab(D65)	dL'-dE000(D65)	dC'-dE000(D65)	
Target	PPSMF20 Production Standard 2023		05/04/2023 12:55:38	SCI	---	---	---	86.92	-2.21	4.59	5.10	115.73	---	---	---	---	---	---	---	---	---	---
Target	PPSMF20 Production Standard 2023		05/04/2023 12:55:38	SCE	---	---	---	85.13	-2.30	4.86	5.37	115.31	---	---	---	---	---	---	---	---	---	---
86	19/08/2025 PPS-FDAMF20-UN 10:05 SAMPLE 2		19/08/2025 10:17:27	SCE	1	---	Fail	83.89	-2.75	4.50	5.27	121.48	-1.24	-0.46	-0.36	-0.10	0.57	1.07	1.37	-0.82	0.12	
			19/08/2025 10:17:43	SCI	1	---	Fail	85.58	-2.65	4.15	4.93	122.51	-1.34	-0.43	-0.44	-0.17	0.59	1.12	1.48	-0.87	0.06	
			19/08/2025 10:17:43	SCE	1	---	Fail	83.93	-2.75	4.42	5.21	121.89	-1.20	-0.45	-0.43	-0.16	0.61	1.08	1.36	-0.80	0.07	
87	19/08/2025 PPS-FDAMF20-UN 10:05 SAMPLE 3		19/08/2025 10:17:55	SCI	1	---	Fail	85.55	-2.66	4.12	4.91	122.82	-1.37	-0.44	-0.47	-0.20	0.62	1.16	1.52	-0.89	0.05	
			19/08/2025 10:17:55	SCE	1	---	Fail	83.87	-2.74	4.37	5.16	122.04	-1.26	-0.44	-0.48	-0.21	0.62	1.11	1.42	-0.83	0.03	
88	19/08/2025 PPS-FDAMF20-UN 11:20 SAMPLE 1		19/08/2025 11:27:47	SCI	1	---	Pass	86.14	-2.55	4.31	5.01	120.59	-0.78	-0.34	-0.28	-0.09	0.43	0.72	0.89	-0.50	0.08	
			19/08/2025 11:27:47	SCE	1	---	Pass	84.52	-2.63	4.56	5.27	119.97	-0.61	-0.34	-0.29	-0.10	0.43	0.66	0.76	-0.40	0.06	
89	19/08/2025 PPS-FDAMF20-UN 11:20 SAMPLE 2		19/08/2025 11:27:59	SCI	1	---	Pass	86.16	-2.54	4.28	4.98	120.73	-0.75	-0.33	-0.32	-0.13	0.44	0.72	0.88	-0.49	0.05	
			19/08/2025 11:27:59	SCE	1	---	Pass	84.57	-2.62	4.52	5.22	120.12	-0.56	-0.32	-0.34	-0.15	0.44	0.65	0.73	-0.37	0.03	
90	19/08/2025 PPS-FDAMF20-UN 11:20 SAMPLE 3		19/08/2025 11:28:13	SCI	1	---	Fail	85.61	-2.62	5.14	5.77	117.03	-1.31	-0.41	0.55	0.67	1.12	1.07	1.47	-0.85	0.63	
			19/08/2025 11:28:13	SCE	1	---	Fail	83.96	-2.71	5.42	6.06	116.54	-1.18	-0.41	0.57	0.69	1.12	1.02	1.37	-0.78	0.64	
91	19/08/2025 PPS-FDAMF20-UN 12:10 SAMPLE 1		19/08/2025 12:20:47	SCI	1	---	Pass	86.07	-2.52	4.26	4.95	120.55	-0.85	-0.30	-0.33	-0.15	0.42	0.75	0.96	-0.55	0.02	
			19/08/2025 12:20:47	SCE	1	---	Pass	84.48	-2.61	4.51	5.21	120.07	-0.66	-0.32	-0.34	-0.16	0.44	0.68	0.81	-0.43	0.02	
92	19/08/2025 PPS-FDAMF20-UN 12:10 SAMPLE 2		19/08/2025 12:21:00	SCI	1	---	Fail	85.63	-2.72	5.34	5.99	117.00	-1.28	-0.50	0.74	0.89	1.12	1.18	1.57	-0.83	0.82	
			19/08/2025 12:21:00	SCE	1	---	Fail	83.95	-2.79	5.65	6.31	116.30	-1.18	-0.50	0.80	0.94	1.10	1.15	1.51	-0.78	0.84	

Figure 9. Example of results of the ΔE measurement on plaques.

Decontamination: An EREMA [redacted] with subsequent thermal-physical cleaning will reduce the remaining VOC and SVOC substances. The minimum residence time in this stage is [redacted] hours.

Finished pellet will be blown to product silos after processing and held on a batch release system pending quality approval.

QC 8 - [redacted] monitoring (Technical document SOP065): twice *per* shift, the heated zones on the HMI are checked and documented with pictures (Figure 10).



Figure 10. pictures of the heated zones on the HMI.

QC 7 - Product testing, and batch release (Technical document SOP025, SOP021, SOP022, SOP018, SOP020, SOP027, SOP019): a minimum of 1 sample *per* batch (usually equivalent to 50 tonnes and 24 hours production), will be analysed *via* a series of physical and chemical testing to prove the suitability of the material.

All finished goods will be held in the silo until satisfactory completion (or failure) of the full Batch Release Protocol (BRP). A dedicated product silo is installed with each having a design capacity of 50 tonnes of pellets. Only one sample *per* silo will be collected, with the autosampler set-up to dispense a small amount of pellets, on a regular basis, throughout the entirety of the silo being filled, making it representative of the silo itself.

The BRP consists of a suite of physical and analytical tests to determine the suitability of the batch for use in contact sensitive applications including FCM. The full BRP will be a live document updated and revised as necessary to ensure compliance with regulatory and customer requirements.

- Headspace GC-MS for VOC NIAS analysis and quantification of specific target materials including Limonene and Benzene
- Extraction and NIAS and toxicological screening for SVOC compounds using polar and non-polar solvents, analysed by GC-MS/FID for optimum quantification
- Specific quantification of customer identified target compounds including PAHs and Phthalates
- XRF analysis for detection of the presence of metals
- Accelerated OM testing using food simulants, including but not limited to iso-octane (*i.e.* 2,2,4 trimethylpentane) and ethanol 95%
- Physical and Rheological testing
 - Tensile
 - Flex
 - Izod
 - MFI
- Colour measurement via spectrophotometer

The result of all the relevant analyses will then be compiled into a Certificate of Analysis (CoA).

The presence of substances of concern, above the safety limits specified in regulation 10/2011 will stop the batch to achieve USD hold release, and it will not be released for sale as primary product quality.

Additional screening will be carried out for non-volatile compounds including LC-MS, at a frequency of minimum once per batch, until such time the data will support a decrease in frequency.

Specifically for the GC analysis, the compounds are reported in mg/Kg of polymer in contact with the food, assuming a thickness of 3mm of polymer. The Safety Migration Limits (SMLs) are specified in ANNEX I of the Commission Regulations (EU) No 10/2011. In Table 1, Column 8, these limits are reported in mg/Kg of food.

The EU standard cube, assumes that 1Kg of food will be in contact with 6dm² of polymer. Assuming a conservative case of 3mm wall thickness, the volume of polymer in 6dm² corresponds to 180cm³. Considering the density of PP being 0.92g/cm³, that volume corresponds to 165.6g of polymer/Kg of food, and therefore 0.1656Kg of polymer/Kg of food. Considering a conservative scenario, an extraction coefficient of 50% is applied. Therefore, conversion mg/Kg of polymer to mg/Kg of food is achieved by multiplication by 0.3312.

Batches will only be released by QC subject to the satisfactory completion of these tests and batches that do not meet the standard will be downgraded to non-food grade materials.

Certificate of Analysis

Product name PP5-FDAMF20
Lot number WR0037669/001
Analysis start date 8/6/2025

Certificate of Conformity
This batch of PP5-FDAMF20 conforms to the process description accepted by the FDA under LNO PNC2780

Analysis	Specification	Result (mgdm ⁻²)
Overall Migration (95% Ethanol)	< 10 mgdm ⁻²	4.2

Analysis	Limit	Element	Result (mgkg ⁻¹)
XRF	-	Ti	4466
XRF	-	Ca	1902
XRF	-	Si	1074
XRF	<100 mgkg ⁻¹	Σ (Pb, Hg, Cd, [Cr(VI)])	<100

GC-MS SCAN method			
Retention Time	Peak area	Compound name	Concentration (mgkg ⁻¹)
17.571	53269	Acenaphthene-d10	4.0
17.818	14333	BHT-quinone-methide	1.1
18.686	30799	2,4-Di-tert-butylphenol	2.3
22.021	9531	Amberonone	0.7
22.142	14619	Octane, 1,1'-oxybis-	1.1
23.861	11460	Octanal, 2-(phenylmethylene)-	0.9
24.100	95152	Phenanthrene-d10	4.0
25.589	94256	Isopropyl myristate	4.0
27.303	22895	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	1.0
29.452	101740	Isopropyl palmitate	4.3
30.489	153055	Stearylalcohol	6.4
31.562	301983	Oleic acid	12.7
31.981	206642	Stearic acid	8.7
33.704	18971	Tributyl acetyl/citrate	0.8
35.175	179248	cis-11-Eicosenamide	7.5
36.250	70376	Chrysene-d12	4.0
37.610	866797	Palmitic acid monoglyceride	49.3
37.943	25912	Bumetizole	1.5
38.057	27879	Bis(2-ethylhexyl) phthalate	1.6
39.903	11408	Octocrylene	0.6
40.670	729997	Stearic acid monoglyceride	41.5
41.022	73676	1,3-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	4.2
42.285	31622	Benzo[a]pyrene - d12	4.0
49.762	512053	Tris(2,4-di-tert-butylphenyl) phosphite	64.8
51.821	881177	2,4-Di-tert-butylphenol mesylate	111.5

Compounds marked in bold are a internal standards used for semi-quantitative analysis

NIAS screening was performed allowing the characterisation of compounds above 10 µgkg⁻¹ in the sample

Certificate of Analysis

Product name PP5-FDAMF20
Lot number WR0037669/001
Analysis start date 8/6/2025

Certificate of Conformity
This batch of PP5-FDAMF20 conforms to the process description accepted by the FDA under LNO PNC2780

GC-MS SIM method for PAH		
Compound name	Limit (mgkg ⁻¹)	Concentration (mgkg ⁻¹)
Acenaphthene	<0.1	<0.1
Acenaphthylene	<0.1	<0.1
Anthracene	<0.1	<0.1
Benzo(a)anthracene	<0.1	<0.1
Benzo(b)fluoranthene	<0.1	<0.1
Benzo(j)fluoranthene	<0.1	<0.1
Benzo(k)fluoranthene	<0.1	<0.1
Benzo(ghi)perylene	<0.1	<0.1
Benzo(a)pyrene	<0.1	<0.1
Benzo(e)pyrene	<0.1	<0.1
Chrysene	<0.1	<0.1
Dibenzo(a,h)anthracene	<0.1	<0.1
Fluoranthene	<0.1	<0.1
Fluorene	<0.1	<0.1
Indeno(1,2,3-cd)pyrene	<0.1	<0.1
Naphthalene	<0.1	<0.1
Phenanthrene	<0.1	<0.1
Pyrene	<0.1	<0.1

GC-MS SIM method for Phthalates		
Compound name	Limit (mgkg ⁻¹)	Concentration (mgkg ⁻¹)
Benzylbutylphthalate	<10	<0.1
Bis(2-butoxyethyl)phthalate	<10	<0.1
Bis(2-ethylhexyl)phthalate	<10	1.6
Bis(2-methoxyethyl)phthalate	<10	<0.1
Diallylphthalate	<10	<0.1
Dibutylphthalate	<10	<0.1
Dicyclohexyl phthalate	<10	<0.1
Diethylphthalate	<10	<0.1
Diisobutylphthalate	<10	<0.1
Diisodecylphthalate	<56	<0.1
Di-isohexylphthalate	<10	<0.1
Diisononylphthalate	<12	<0.1
Diisopentylphthalate	<10	<0.1
Dimethylphthalate	<10	<0.1
Di-n-hexylphthalate	<10	<0.1
Di-n-octylphthalate	<10	<0.1
Dinonyl phthalate	<10	<0.1
Dipentylphthalate	<10	<0.1

Certificate of Analysis

Product name PPS-FDAMF20
Lot number WR0037669/001
Analysis start date 8/6/2025

Certificate of Conformity
This batch of PPS-FDAMF20 conforms to the process description accepted by the FDA under LNO PNC2780

HS GC-MS SCAN method			
Retention Time	Peak area	Compound name	Concentration (mgkg ⁻¹)
5.558	3509815	Pentafluorobenzene	0.10
6.146	5657417	1,4-Difluorobenzene	0.10
8.436	4000056	Chlorobenzene-d5	0.10
9.469	1537365	Unknown	0.04
10.316	4803741	Limonene	0.12
10.383	11142888	1,4-Dichlorobenzene-d4	0.10
10.507	1418094	2-Propyl-1-pentanol	0.04
11.019	3370579	Unknown	0.08
11.119	3110951	Undecanol-4	0.08
12.044	3530713	Menthol	0.09
12.194	6838316	α-Terpineol	0.17
12.805	14521411	Triethylene glycol	0.36
12.974	14235479	ortho tert-Butyl cyclohexyl acetate	0.36

Compounds marked in bold are a internal standards used for semi-quantitative analysis
NIAS screening was performed allowing the characterisation of compounds above 10 µgkg⁻¹ in the sample

HS GC-MS SIM method for benzene and limonene		
Compound name	Limit (mgkg ⁻¹)	Concentration (mgkg ⁻¹)
Benzene	<0.1	<0.01
Limonene	<0.5	0.12

Physical testing			
Property	Expected Value	Units	Result
MFI	15 -21	g.10mins ⁻¹	18.2
Impact	>5.0	kJ.m ⁻²	5.5
Density	0.90 - 0.92	g.cm ⁻³	0.91
Flexural Modulus	1300 - 1900	MPa	1732
Tensile Stress at Yield	25 - 35	MPa	30
Elongation at Break	>20	%	30.0
PP Content (DSC)	-	%	99.6
Colour (CIELAB 1976)			
L*	86.9	-	87.0
a*	-2.2	-	-2.3
b*	4.6	-	4.8
c*	5.1	-	5.4
h*	115.7	-	115.8
ΔE (dE2000 SCI)	<2.5	-	0.3

The above information is based on process controls and evaluations

Compiled by:	Shweta Neve
Signature	
Title	Analytical Chemist
Date	8/7/2025
Approved by:	Nur Zulkifli
Signature	
Title	Senior Analytical Chemist
Date	8/7/2025

Figure 11. Example of a Certificate of Analysis. Page 1/3 shows the OM analysis, and GC-MS SCAN method; Page 2/3 shows the GC-MS SIM method for PAH and Phthalates; Page 3/3 shows the Headspace GC-MS analysis, the physical testing, and the two-signature approval.

Ongoing Process Control

In addition to the testing and sampling data shown above ongoing process control data collection will be carried out as required, based on analysis of the stability of the process at different stages.

These checks will include but are not limited to;

- Regular testing of MFI – finished pellet from after pelletisation
- Colour sampling and measurement – finished pellet from after pelletisation
- Wash and rinse water quality (colour/clarity/pH/smell) – final rinse
- Moisture - finished pellet from after pelletisation

As well as the sampling and testing regiment outlined above, the plant is fitted with an integrated SCADA data collection system (**Figure 12**). Inline monitoring of several critical parameters are collected and recorded as part of the operational quality plan, and data is stored alongside that from the direct intervention samples described above.

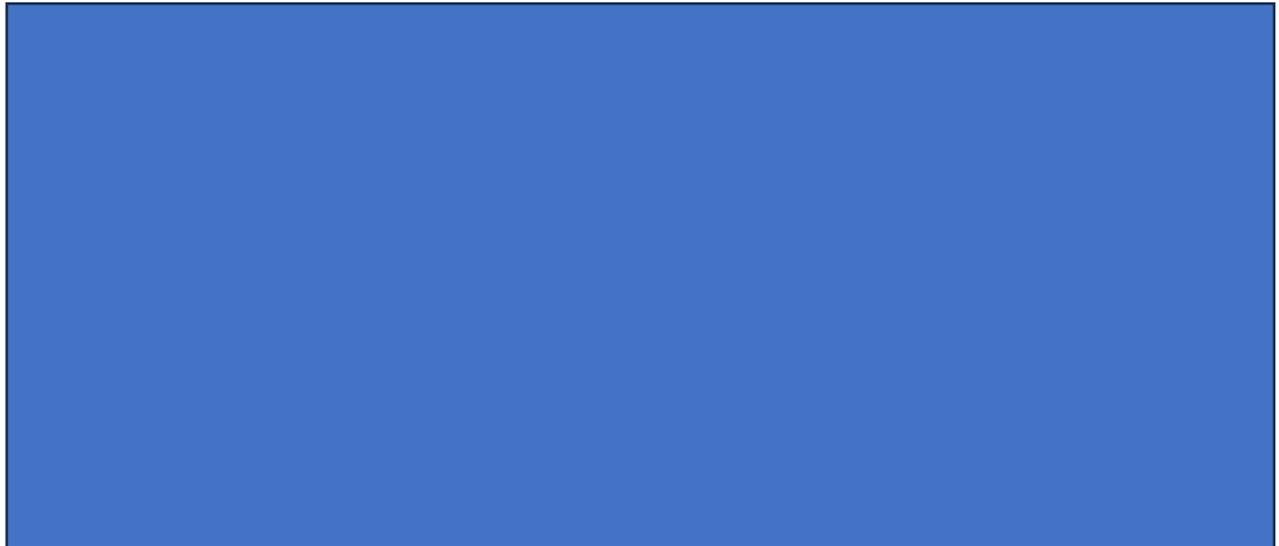


Figure 12. Screenshot from the integrated SCADA data collection system.

Decontamination efficiency from flakes to pellets

A sampling process will be established, in order to correlate the input stream and the final product as closely as possible.

For illustrative purposes only, an example comparing the GC-MS analysis of the flakes and the final products is provided to estimate the decontamination efficiency of the process. **Table 1-2** shows the analysis of one Silo of finished product vs an input flake sample taken 24 hours prior to production. **Additional data continues to be collected and will be provided on an ongoing basis to the URL.**

Silo 4, WR0037714-001

Production date: 11-08-2025

Unwashed flakes date: 10-08-2025

The HS GC-MS analysis (**Table 1**) of the flakes shows efficient removal of volatiles compounds, as evidenced by the absence of all contaminants with retention times before Limonene. For Limonene, Isodecyl-methacrylate, beta-Ocimene, d-Menthol, Alpha Terpeneol, and 4-tert-Butylcyclohexyl acetate implied decontamination efficiencies, above 97% were achieved.

Table 1. Headspace GC-MS analysis of input flake compared to the final pellets.

Headspace GC-MS analysis			
Compounds (b)	Concentration (a)		Implied decontamination efficiency (%)
	UWF	Pellets	
Disulfide, dimethyl	0.06		~ 100
Ethylbenzene	0.03		~ 100
o-Xylene	0.14		~ 100
2-Heptanone	0.29		~ 100
Alpha-pinene	1.41		~ 100
Benzene 1 ethyl 4 methyl	0.08		~ 100
Benzene 1,2,4 trimethyl	0.74		~ 100
Limonene	9.43	0.09	99
Gamma-terpinene	0.87		~ 100
Isodecyl methacrylate	0.71	0.02	97
2 Carene	9.86		~ 100
beta-Ocimene	1.58	0.03	98
Fenchyl acetate	3.45		~ 100
L-Menthone	0.75		~ 100
Camphor	0.38		~ 100
d-Menthol	3.32	0.06	98
Alpha-Terpeneol	14.97	0.01	99
Triethylene glycol	2.28	0.52	77
4-tert-Butylcyclohexyl acetate	0.25	0.01	94

a. the concentration is reported as mg/Kg of polymer, and is obtained with $C_{\text{compound}} = (A_{\text{compound}}/A_{\text{IS}}) * C_{\text{IS}}$, where A_{compound} and A_{IS} are the areas of the peaks of the compounds and nearest Internal Standard and C_{IS} is the concentration of the Internal Standard, spiked at 0.1mg/Kg of polymer. **b.** Only substances with a MS library match >80% are reported.



A specific migration of the unwashed flakes is carried out with the same conditions of the final product (12h, in Hexane/Acetone 50:50 V/V, followed by 10x concentration). For SVOC the process shows a lower decontamination efficiency, but it still brings the concentrations below the SMLs outlined in regulations 10/2011. (Table 2).

Table 2. GC-MS/FID analysis of UWF compared to the final pellets, produced with them.

GC-MS analysis			
Compounds (b)	Concentration (a)		Implied decontamination efficiency (%)
	UWF	Pellets	
BHT-quinone-methide	4.27		~ 100
Triisopropyl(ethoxy) silane	1.80		~ 100
2,4-Di-tert-butylphenol	5.42	1.96	64
Dodecanoic acid	8.36		~ 100
Diethyltoluamide	2.20		~ 100
Isocitronellol	2.08		~ 100
Amberonne	2.36	0.51	78
n-Hexyl salicylate	0.78	0.35	55
Amberonne (isomer 3)	0.97		~ 100
Octanal, 2-(phenylmethylene)-	2.30		~ 100
Tetradecanoic acid	5.12		~ 100
2-Ethylhexyl salicylate	0.75		~ 100
Octadecanoic acid	0.21		~ 100
Stearic acid	0.60		~ 100
Homosalate	0.64		~ 100
7,9-Di-tert-butyl-1-	0.24		~ 100
Palmitic acid	8.55		~ 100
Oleic acid	54.97	2.6	95
Stearic acid	8.75	3.2	64
Palmitic acid amide	0.57		~ 100
Tributyl acetylcitrate	3.57		~ 100
Oleic acid amide	7.28	1.22	83
Bumetrizole		1.19	~ 100
Erucic acid amide	10.20		~ 100
Tris(2,4-di-tert-butylphenyl)	108.25	47.84	55
Oleoyl chloride	2.09		~ 100

a. the concentration is reported as mg/Kg of polymer, and is obtained with $C_{\text{compound}} = (A_{\text{compound}} / A_{\text{IS}}) * C_{\text{IS}}$, where A_{compound} and A_{IS} are the areas of the peaks of the compounds and nearest Internal Standard and C_{IS} is the concentration of the Internal Standard, spiked at 4.0 mg/Kg of polymer. The peaks areas are obtained with GC-FID. **b.** Only substances with a MS library match >80% are reported.

Safety Case

Decontamination efficiency as demonstrated by Challenge Testing

To determine the decontamination efficiency of the overall process, a Challenge Test was performed, as detailed in Section 5.2 of the “*Scientific Guidance (EFSA 2004)*”. The PP was purposely doped with selected contaminants and then subjected to the recycling process technology, specifically, this Challenge Test was carried out to assess the effectiveness of a “super clean” recycling process (EREMA technology). The model contaminants (surrogates) were chosen following the guidance in Section 5.2 and doped at a concentration above the typical concentration found in post-consumer PP flakes. Chloroform is aggressive to PP, so it was solely used to promote swelling and adequate adsorption of the surrogates on the polymer. Therefore, Chloroform wasn’t quantitatively analysed. The flakes were spiked, and then incubated at high temperature, to enable the surrogates to diffuse into the PP. The spiking was done at the Fraunhofer IVV and the challenge test was carried out in a pilot plant.

150kg of flakes filled into six barrels (25kg each), and to each barrel was added a mixture of 25mL toluene, 25mL chlorobenzene, 25mL chloroform, 25mL methyl stearate, 25mL phenyl cyclohexane, 25g benzophenone, and 25g methyl stearate. The sealed barrels were turned/rolled each day and after contamination, the flakes were rinsed with 10% ethanol and centrifuged to remove surface moisture. 2g of each sample was extracted with 10 mL dichloromethane for 24h at 40°C, and analysed by GC-MS/FID (Agilent 6890, column: DB 1 – 30m – 0.30mm i.d. – 0.25µm film thickness, temperature program: 50°C (4min), heat at 15°C/min to 260°C (10min), Split 10mL/min).

Table 3. results of a post-consumer PP challenge test performed by the Fraunhofer for Erema. Full report can be found in the resource section of the URL.



Table 3 demonstrates the decontamination of the Erema process on PP. The decontamination applies to already migrated production ink species (at a safe level before input), polymer additives and any decomposition products from residue paper or printing ink systems.

The quality management system of Fraunhofer IVV, meets the requirements of DIN EN ISO/IEC 17025:2018 and hence also the requirements of ISO 9001:2015 for the test laboratories. Their test laboratories were re-accredited (D-PL-11140-04-00) in 2016 by the DAkkS (Deutsche Akkreditierungsstelle), the national accreditation body of the Federal Republic of Germany. Their method development was confirmed by the re-accreditation 2000, 2006, 2011, 2012 and 2016 as well as the control audit in 2021.

Input and Output Characterisation

During the development of the technology, it has been possible to carry out a few pre-production trials to illustrate the effectiveness of the process at delivering material to the required standard of compliance.

In the Resources section of the URL are several independent analytical reports on the various pre-production batches of the resin, replicated in full.

During these trials it was only possible to replicate elements of the Technology, having not had all these elements assembled in one location until the operational facility was completed. The final process therefore will, in fact, be better than the trials. However, in all cases, despite this, the analytical findings demonstrate high levels of decontamination and compliance with applicable FCM regulations.

TRIAL 1- Summary

The detailed analysis for the PP compound generated by trial 1 is summarised below. In this trial no extraction of food grade material was attempted, at any point, and the colour sorting was done after washing. This means a full white/jazz split was carried out on the flake sorting system and as such produced a less pure white than we would expect from a pre-sort carried out on NIR belt systems. A Jazz PP was also produced and analysed, and this contains all the material rejected from the white stream.

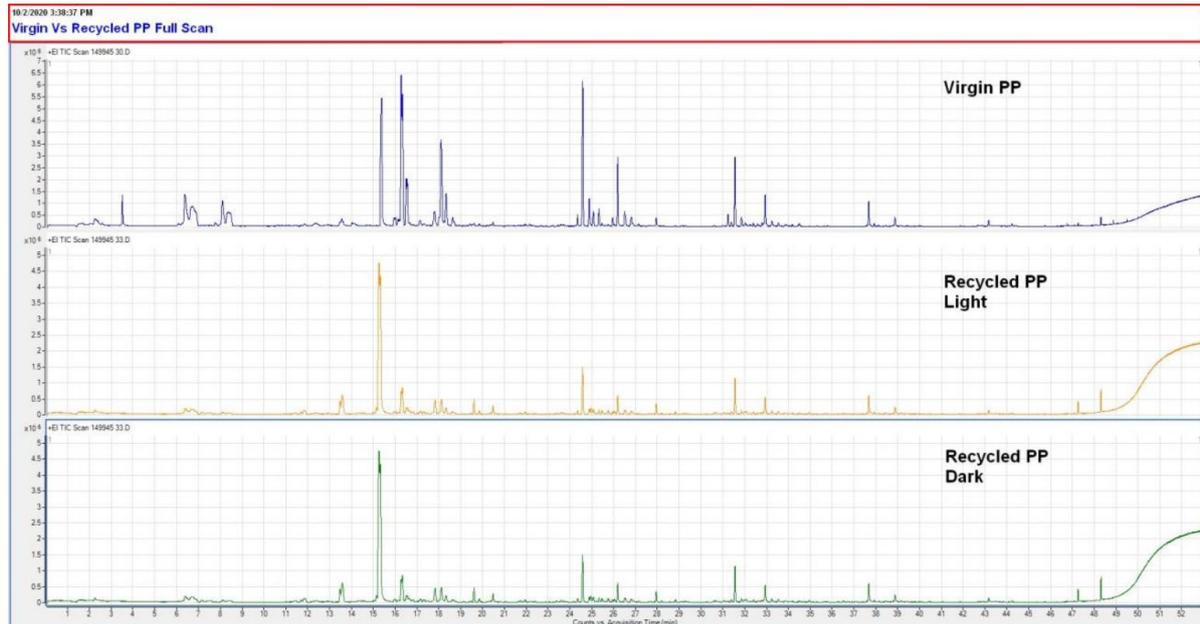


Figure 13. Headspace analysis - Virgin PP v Trial 1 products.



Figure 14. Solvent Extraction Analysis – Trial 1

Overall migration results were compliant, and no peaks of concern were found in specific migration of both compound under the conditions below.

Table 4. Overall Migration of the PP Compounds

Simulant	Test Conditions	Migration results (mg/dm ²)			Mean Migration (mg/dm ²)
10% V/V Ethanol	10 days @ 20°C	<0.06	<0.06	<0.06	<0.1
50% V/V Ethanol	10 days @ 40°C	0.55	<0.06	0.5	0.4

The FDA version of the test was also applied. These tests were carried out on a blend of 30% rPP and 70% virgin PP.

Table 5. FDA Total Extractives.

Sample	Simulant	T (°C)	Exposure time	Total Extractives	Mean Total Extractives (mg/ln2)	Total Extractives Limit (mg/ln2)
PP light 30%/Virgin 70% - 7h refreshed W11818/1	Deionised water	48.9	2 hours	0	0	0.5
				0		
				0		
	Heptane	48.9	15 minutes	0.63	0.62	0.5
				0.56		
				0.67		
	8% Ethanol	65.6	2 hours	0.09	0.1	0.5
				0.07		
				0.1		
	50% Ethanol	65.6	2 hours	0.2	0.1	0.5
				0.1		
				0.03		

The sample PP light 30%/ Virgin 70% - 7 hours refreshed, did exceed the limit of 0.5mg/ln2 with Heptane. Following chloroform soluble with the residue, the limit was not exceeded. PP light 30%/Virgin 70% - 7 hours refreshed did not exceed the limit of 0.5mg/ln2, as set out in FDA CFR 21, with any other simulants. Therefore, the sample is suitable for contact with all food under conditions C to G.

In addition, a heavy metals and REACH compliance check was made with conclusions shown in **Figure 15**.



Conclusion

Overall Migration EU 10/2011

Sample, PP light 30%/Virgin 70% - 7hr refreshed, meets the overall migration limits of 10 mg/dm² as set out in EU 10/2011 at OM5 conditions of use. These are intended to cover high temperature applications up to 121 °C. Test OM5 covers also food contact conditions described for OM1, OM2, OM3, and OM4. It represents the worst case conditions for all food simulants in contact with polyolefins.

Please note that full compliance with the requirements of 10/2011 include showing that the sample does not contravene Article 3 of 1935/2004, which requires that no substances can migrate in quantities harmful to human health.

FDA Total Extractives and Chloroform Solubles Testing

Sample, PP light 30%/Virgin 70% - 7hr refreshed, did exceed the limit 0.5 mg/in² with Heptane. Following chloroform solubles with the residue, the limit was not exceeded. PP light 30%/Virgin 70% - 7hr refreshed did not exceed the limit of 0.5 mg/in² as set out in FDA CFR 21 with any other simulants. Therefore, the sample is suitable for contact with all foods under conditions C to G.

VOC Testing NOT TO UKAS

Sample, PP light 30%/Virgin 70% - 7hr refreshed, did not exceed the client's limit of 0.5 ppm D-Limonene. Sample, PP light 30%/Virgin 70% - 7hr refreshed, did not exceed the client's limit of 0.1 ppm Benzene.

Packaging and Packaging Waste Directive

Sample, PP light 30%/Virgin 70% - 7hr refreshed, did not exceed the limit of 100 ppm for the sum of lead, cadmium, chromium, and mercury as set out in Directive 94/62/EC.

REACH and Phthalate testing NOT TO UKAS

Concerning the tested parameters, the item is free of hazardous substances listed in the SVHC candidate list of the REACH-regulation in a concentration greater than 0.1%. There are no obligations according art 33 of the REACH regulation.

Sample, PP light 30%/Virgin 70% - 7hr refreshed, did not exceed the following limits of phthalates: DiDP 56 ppm, DiNP 12 ppm and all others 10 ppm each.

Figure 15. Extract from Intertek report IWTN-W000011818RLM001 Amcor.

Please note again that the materials tested were not sorted to remove non-food polymers and so show a very much worst-case scenario. This scenario, however, shows the material is of a quality where it would be safe for food contact.

Additional trials

Further trials were carried out in the development of the process, to provide sample materials for customer approval and processing trials. These samples were pellets of 100% rPP, produced according to the method discussed in this document. Details of 2 of these can be found in Intertek report FUFDCP2022-00752-Final and extracts from this are shown below.

Sample-No.	Sample Description
1	PP5FDAMF20 (Batch: November 2021)
2	PP5FDAMF20 (Batch: Augustuts 2021)

1. Global migration

Method: DIN EN 1186:2002-07 / 2002-12

LoQ: 6.0 mg/L

Uncertainty of measurement: ± 12 mg/L for acetic acid 3%, Ethanol 10% and 50%;

± 18 mg/L for Ethanol 95% and i-octane

Requirement max. 60 mg/kg food simulat

Testing procedure: total immersion, 10 g / 100 ml

a) Testing conditions: Acetic acid 3% (10d / 40°C)

Sample	No. 1	No. 2
Global migration mg/L	23	13

b) Testing conditions: Ethanol 10% (10d / 40°C)

Sample	No. 1	No. 2
Global migration mg/L	19	23

c) Testing conditions: Ethanol 50% (10d / 40°C)

Sample	No. 1	No. 2
Global migration mg/L	10	15

d) Testing conditions: Ethanol 95% (10d / 40°C)

Sample	No. 1	No. 2
Global migration mg/L	13	10

e) Testing conditions: iso-octane (10d / 40°C)

Sample	No. 1	No. 2
Global migration mg/L	20	17

Figure 16. Overall Migration August 21 trial and November 21 trial (FUFDCP2022-00752-Final).

Figure 16 shows OM figures are well below the thresholds of 60mg/kg for all tested food simulants. This has been a feature of all analysed materials.

2. Specific migration of phthalates

Test method: DIN EN 13130-1:2004-08 / GC-MS*

Testing conditions: Ethanol 95% (10d / 60°C), total immersion of 10g / 100ml

SML = specific migration limit

Phthalates in mg/L simulant

Parameter	Abbrev.	CAS- No.	No. 1	No. 2	LOQ	SML in mg/kg food simulant
Dibutyl-phthalate	DBP	84-74-2	n.d.	n.d.	0.1	0.3
Benzylbutyl-phthalate	BBP	85-68-7	n.d.	n.d.	1.0	30
Bis-(2-ethyl-hexyl)phthalate	DEHP	117-81-7	n.d.	n.d.	1.0	1.5
Di-n-octyl-phthalate	DNOP	117-84-0	n.d.	n.d.	1.0	---
Diisononyl-phthalate	DINP	28553-12-0 68515-48-0	n.d.	n.d.	1.0	9
Diisodecyl-phthalate	DIDP	26761-40-0	n.d.	n.d.	1.0	
Diallylphthalate	DAP	131-17-9	n.d.	n.d.	0.01	<0.01

Figure 17. Specific Migration of Phthalates August 21 trial and November 21 trial (FUFDPC2022-00752-Final).

Analysis for the presence of Phthalates (**Figure 16**) has been carried out on trial materials and shows consistently that these are present (if detectable at all) at levels well below any threshold of concern.

3. Migration of metals

Test method: DIN EN 13130-1:2004-08 / ICP-OES: DIN EN ISO 11885: 2009-09 + ICP-MS: DIN EN ISO 17294-2: 2017-01 + AFS (Hg): DIN EN ISO 17852: 2008-04

Testing conditions: Acetic acid 3% (10d / 60°C), total immersion of 10g / 100ml

SML = specific migration limit

ND = not detectable

Results in mg/L simulant

Element	No. 1	No. 2	LOQ (mg/L)	SML (mg/kg food simulant)
Aluminum	n.d.	0.11	0.10	1
Arsenic	n.d.	n.d.	0.01	ND (<0.01)
Barium	n.d.	0.010	0.01	1
Cadmium	n.d.	n.d.	0.002	ND (<0.002)
Cobalt	n.d.	n.d.	0.01	0.05
Chromium	n.d.	n.d.	0.01	ND (<0.01)
Copper	n.d.	0.012	0.01	5
Europium	n.d.	n.d.	0.01	0.05
Iron	n.d.	n.d.	0.01	48
Gadolinium	n.d.	n.d.	0.01	0.05
Lanthanum	n.d.	n.d.	0.01	0.05
Lithium	n.d.	n.d.	0.01	0.6
Manganese	n.d.	n.d.	0.01	0.6

Figure 18. Migration of Metals August 21 trial and November 21 trial (FUFDPC2022-00752-Final).

4. Specific Migration of Polycyclic Aromatic Hydrocarbons (PAH) in µg/L

Test method: DIN EN 13130-1:2004-08 / GC-MS*

Testing conditions: iso-octane (10d / 60°C), total immersion of 10g / 100ml

LoQ: 10 µg/L

Substances	CAS-No	No. 1	No. 2
1 Naphthalene	91-20-3	n.d.	n.d.
2 Acenaphthylene	208-96-8	n.d.	n.d.
3 Acenaphthen	83-32-9	n.d.	n.d.
4 Fluorene	86-73-7	n.d.	n.d.
5 Phenanthrene	85-01-8	n.d.	n.d.
6 Anthracene	120-12-7	n.d.	n.d.
7 Fluoranthene	206-44-0	n.d.	n.d.
8 Pyrene	129-00-0	n.d.	n.d.
9 Benzo(a)anthracene	56-55-3	n.d.	n.d.
10 Chrysene	218-01-9	n.d.	n.d.
11 Benzo(b)fluoranthene +	205-99-2 +	n.d.	n.d.
12 Benzo(j)fluoranthene	205-82-3		
13 Benzo(k)fluoranthene	207-08-9	n.d.	n.d.
14 Benzo(e)pyrene	192-97-2	n.d.	n.d.
15 Benzo(a)pyrene	50-32-8	n.d.	n.d.
16 Indeno(1,2,3-cd)pyrene	193-39-5	n.d.	n.d.
17 Dibenzo(a,h)anthracene	53-70-3	n.d.	n.d.
18 Benzo(ghi)perylene	191-24-2	n.d.	n.d.
sum		n.d.	n.d.

Requirement: not detectable (LOQ = 10µg/kg)

Figure 19. PAH Analysis August 21 and November 21 Sample (FUFDCP2022-00752-Final).

4. Testing according to packaging ordinance 94/62/EC

Analysis of cadmium, chromium, lead and mercury, test results in mg/kg

Test method:

Digestion: Microwave HNO₃/H₂O₂

Measurement: ICP-OES: DIN EN ISO 11885 (2009-09) for No. 1

ICP-MS: DIN EN ISO 17294-2 (2017-01) for No. 2

Hg: AFS: DIN EN 17852 (2008-04)

Requirement: cumulative ≤ 100 mg/kg

Substance name	CAS No.	LOQ	No. 1	No. 2
Cd	7440-43-9	1 mg/kg	n.d.	n.d.
Cr	7440-47-3	5 mg/kg	n.d. ⁽¹⁾	n.d. ⁽¹⁾
Pb	7439-92-1	5 mg/kg	n.d.	n.d.
Hg	7439-97-6	1 mg/kg	n.d.	n.d.
Status			passed	passed

⁽¹⁾ Due to the obtained Chromium total content the Chromium VI content can be assumed as < 25 mg/kg.

Status acc. to packaging directive 94/62/EC: passed

Conclusion:

Based on the applied tests the sample complies with the packaging ordinance.

Figure 20. Heavy Metal Analysis 94/62/EC August 21 trial and November 21 trial (FUDCP2022-00752-Final).

Conclusion:

The item is free of hazardous substances listed in the SVHC candidate list (8th of July 2021) of the REACH-regulation in a concentration greater than 0.1%. There are no obligations according to article 33 of the REACH-regulation or in the SCIP database of Echa.

Figure 21. Compliance statement REACH SHVC list (FUDCP2022-00752-Final).

In addition, these materials were screened for SHVC and concluded to be compliant with this regulation, as was found with the initial batch trials.

In conclusion, all analysis carried out to date has demonstrated that despite the full process not yet being available and the full selection for food use items not being possible, compliance and safety will not be compromised.

Nevertheless, the process will be fully monitored, and the Batch Release Process will be followed to ensure this remains the case.

Intertek is accredited with ISO17021.

Intended Uses

The intended use for this material is packaging items for food and other contact sensitive applications (e.g. cosmetics and personal hygiene) products. Usage rates should be at the recommended additional rate (as defined in the Declaration of Conformity) but in principle up to 100% recycled content.

Packaging may be produced using all commercially available conversion technologies including but not limited to injection moulding thermoforming, extrusion and Injection blow moulding.

As required by the regulations, individual batches of food grade material will be supplied alongside a certificate of conformity detailing maximum recycled content usage in the final item, depending on the conditions of use and food type. These will be amended depending on the results of the analytical testing, if required.

Conformity and Derogation from Article 6

The process conforms to the guidance set out in Article 6 as follows;

Section 1: Requirements for collection and pre-processing

Waste management operators that participate in the supply chain of plastic input shall ensure that the collected plastic waste meets the following requirements:

(a) the plastic waste originates only from municipal waste, or from food retail or other food businesses if it was only intended and used for contact with food, including waste discarded from a recycling scheme in accordance with Article 9(6);

Input to the process is pre-sorted PP packaging waste from audited MRF and PRFs taking mixed recycling from UK & EU local authority and/or EPR contractors.

(b) the plastic waste originates only from plastic materials and articles manufactured in accordance with Regulation (EU) No 10/2011 or recycled plastic materials and articles manufactured in accordance with this Regulation;

As a result of the sorting and selection criteria laid out earlier in this document the minimum purity or the input to the washing stage will be 95% food use items in last use. Since single use packaging in the waste stream is currently >90% virgin material compliant with Regulation (EU) No 10/2011 this can be assumed for the non-food content as well, meaning that the composition of the material will be >99% compliant with 10/2011.

Hand sorting feedback to the AI identification system which is regularly reviewed will maintain this level over the long term.

(c) the plastic waste is subject to separate collection;

Only schemes which are collecting separated or mixed recycling will be authorised suppliers to the process.

(d) the presence of plastic materials and articles that are different from the plastic for which the decontamination process is intended, including caps, labels and adhesives, other materials and substances, and remaining food is reduced to a level specified in the requirements for the plastic input provided by the recycler and which shall not compromise the achieved level of decontamination.

As laid out in the process description, the infeed section of the process contains size exclusion, dry trammel systems, coupled with wet granulation and caustic hot wash to remove physical contaminants as described in the section above.

Assessment Criteria

Assessment criteria for individual recycling processes utilising the CleanStream® Technology the recycler should provide, at a minimum;

- Full process description demonstrating compliance with all steps as laid out in the process description above, including sorting and separation
- Evidence that the process will provide the required differentiation of food-use and non-food use items in the local specific stream to meet the minimum input purity requirements as laid out above
- Supplier audits to confirm compliance with EC 2022/1616 Article 6
- Analytical test data and process control data in line with the quality protocols set out in stage 2 and 3 or the Quality and Sampling Strategy and in line with the Batch Release Protocol

Development Opportunities

CleanStream® is designed to be a demonstration of a technological principle and subject to successful application and installation will be the basis of further investment across EU and the rest of the world. It is foreseen that the process would be available exclusively to Amcor and its subsidiaries.



Appendix 1: Summary Description for Registration

CleanStream® is a recycling process taking in kerbside recovered waste PP.

Incoming material is subject to **several integrated decontamination steps** and all these forms the basis of the Novel Technology – individual steps would not constitute a recycling process covered by this application.

Mixed colour polypropylene post-consumer Pots, Tubs, and Trays (PTT) are pre-sorted at a MRF or PRF. From this feedstock, the white and clear non-bottle fraction is isolated and defined as the input for the food grade production.

The isolation process consists of 3 layers of automatic sorting, ending with an AI backed object recognition stage capable of providing an infeed which is >95% previous food use packaging. A hand sort follows to verify and ensure compliance.

This fraction is washed free of physical contamination, and a chemical wash removes most of any direct printing inks. A density separation stage removes any PP with a density above 1 and so removes any filled PP \geq 10% filler.

Washed flakes are optically sorted, on both sides, to remove any coloured polymer and flakes that still have a material amount of printing ink on them. Print system remaining will be \leq 400ppm.

Flakes are \geq 99% plastic that meets EU Regulation 10/2011 and \geq 95% PP which was in direct food contact on its last use cycle.

Flakes are processed in an Interema/Refresher combination which degasses, filters and super-cleans the PP. This process has been challenged tested by Erema and decontamination efficiencies are shown later in this document.

All output material will be screened on a batch release basis using on-site analytical techniques, including XRF and GC-MS/GC-FID, for NIAS and specific contaminants (PAH/Phthalates/Heavy Metals) according to customer specific requirements and applicable packaging regulations.



CleanStream® Process Description

Appendix 2 - Process Flow-Chart Detail

Plasgran Clean Stream® Process

