Recyclability Evaluation Service

Recyclability Testing Results

RES

Brand X

Paper Bag with Plastic Inner Liner

Score: 89

Assessed using CEPI 4EG Harmonised Testing Methodology (Part 1) for a recycling mill with conventional process

The CEPI Harmonised Testing Methodology and 4evergreen Recyclability Evaluation Protocol is designed to evaluate the recyclability of an unused/pre-consumer packaging product.

As well as testing the actual material(s) which comprise a packaging product, it is also important to consider its intended use-case/contents.

Regardless of test score, the acceptance of products for recycling is at the discretion of the mill. E.g. a product containing prohibitive materials may be rejected by a recycling mill with conventional process, despite a positive score when tested against the CEPI 4EG procedure.

Test Provider	DS Smith
Test Location	Fibre & Paper Development Laboratory, Kemsley Paper Mill, UK.
Test Evaluator	DS Smith Recyclability Lab Technician Name

Sample Information	
Customer	XXXX
SO Number	XXXX
Sample Name	Paper Bag with Plastic Inner Liner
Date Tested	XXXX

SAMPLE

Recyclability Score

89 / 100

Suitable for Standard Mill Recycling*

*Technically recyclable in a recycling mill with conventional process

The CEPI Harmonised Testing Methodology and 4evergreen Recyclability Evaluation Protocol is designed to evaluate the recyclability of an unused/pre-consumer packaging product.

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Recyclability Evaluation Service

Report Contents

Methodology

CEPI Harmonised Testing Methodology

The Confederation of European Paper Industries (CEPI) is the European association representing the paper industry.

CEPI takes a long-term strategic perspective on issues affecting the industry. As a non-profit organisation, it has four main objectives:

- To secure the pulp and paper industry's competitiveness towards EU policy makers
- To represent the paper industry with EU institutions and Brussels-based stakeholders
- To improve the image and visibility of the paper industry and other related industries
- To be the example of how competitiveness and sustainability can go hand in hand

The CEPI Recyclability Testing Methodology was developed to define a harmonised test method as a basis for assessing the general recyclability of new paper and board-based materials and products which are emerging onto the market. Determining recyclability is necessary to maintain and further increase the sustainability and circularity of the paper and board value chain.

The CEPI Recyclability Testing Methodology defines a laboratory procedure emulating the most relevant phases (pulping, screening, sheet formation) of a paper recycling mill with conventional processes dedicated to recycling the most common conventional grades of paper and board, without flotation-deinking technology or other specialist features.*

DS Smith's Recyclability Evaluation Service adheres to Version 3 of CEPI's Recyclability Laboratory Test Method, which was published in February 2025.

*Text taken from: CEPI website

Methodology

4evergreen Recyclability Evaluation Protocol

4evergreen (4EG) is an initiative of CEPI, falling under their 'Sustainability & Circularity' policy area.

It is an industry alliance which brings together over 100 paper and board producers, packaging converters, brand-owners and retailers, technology and material suppliers, waste sorters and collectors from across the fibre-based packaging value chain.

The overall aim of 4evergreen is to boost the contribution of fibre-based packaging in a circular and sustainable economy that minimises adverse environmental impact. The alliance works to develop tools and guidance for different aspects of fibre-based packaging sustainability and circularity. They aspire for the industry in Europe to reach a 90% recycling rate for fibre-based packaging by 2030.

The 4evergreen Recyclability Evaluation Protocol builds on the Recyclability Laboratory Test Methodology, by giving the industry a common tool to evaluate the technical recyclability of current and future fibre-based packaging materials.

The output values from the laboratory testing procedure are considered by the 4evergreen Recyclability Evaluation. In order to translate the output values into one final Technical Recyclability Score, the results of the following parameters are considered:

- Total Screening Yield
- Dissolved and Colloidal Substances
- Visual Impurities
- Sheet Adhesion

Your overall Technical Recyclability Score is the sum of these four individual scores. *

4evergreen
perfecting circularity together

*Text taken from: 4evergreen website

Methodology

'Paper Recycling Mill with Conventional Process' Definition

The **CEPI Harmonised Testing Methodology** and **4evergreen Recyclability Evaluation Protocol** carried out on your packaging product is a procedure designed to understand how a product would behave in a paper recycling mill with conventional process, without flotation-deinking technology or other special features to recycle paper for producing new paper and board.

It is important to note that a negative assessment reported for one recycling process type does not exclude further testing to be performed for another recycling process type. Recyclability scores derived for one recycling process type cannot be transferred to other recycling process types.

Below is the description detailing what is classed as a Recycling Mill with Conventional Process:

Most recycling mills with conventional process utilise the EN 643 paper grades (groups 1-4). The typical process steps in a recycling mill with conventional process are as follows:

REPULPING

The purpose of repulping is to break down the paper into fibres and other paper components (fillers, inks, varnishes, coatings, etc.). In this step, the paper for recycling is mixed with warm water (40°C - 50°C) of pH 6-7. Conventional mills typically operate a low consistency pulper (4-5% fibre concentration) in continuous mode. Batch pulping may also be used but is less common in the industry. Average retention time in the pulper is 5-10min.

COARSE AND FINE SCREENING

Screening is the process of removing impurities from the pulp, to separate the contaminants from the fibres. It is based on particle size, shape and rigidity difference between fibre and non-fibre components or non-fully dispersed fibre flakes. It can be divided into coarse and fine screening. Coarse screening (often combined with de-flaking to further disperse fibre flakes into individual fibres) is performed after the pulping step at a medium stock concentration (2.5- 4.0%). The fibre suspension flows through screening holes where large contaminants are retained (typical hole diameters 2-3mm) while fibres can pass freely through.

The objective of the fine screening is to remove smaller-sized particles (e.g. adhesives, smaller particles) from the pulp. Fine screening is generally done at medium or low concentration (1-2.5%) through slotted baskets (typical slot size 0.15-0.4mm). Screening is often operated in cascaded systems and recycling mills may have one or more steps of coarse and fine screening in accordance with the process efficiency and target quality of recycled pulp.

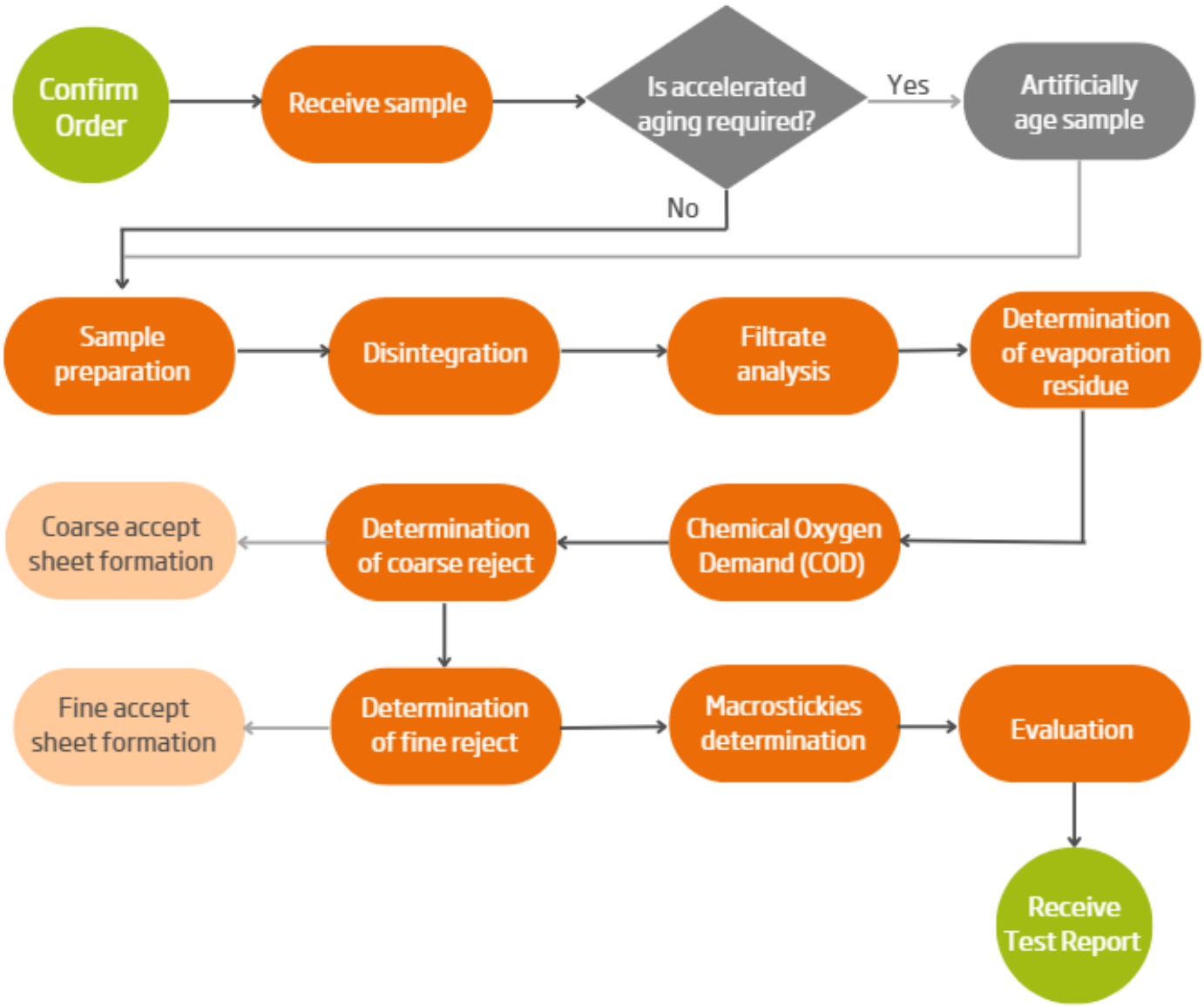
CLEANING

After pulping, the fibre slurry can be fed into hydrocyclones (so-called 'cleaner') to separate impurities that have different densities from fibres and water. In general, conventional mills have high-density cleaners at a stock concentration of 3-4% to separate the bigger or heavier contaminants like staples and small stones. Heavy contaminants of a smaller size (e.g. sand) are taken out by low-consistency hydro-cyclones (stock concentration 0.5- 1.5%). In many cases the low-density debris (e.g. expanded polystyrene) are also separated in these hydro-cyclones (so-called lightweight cleaner).

PAPERMAKING

After the screening and cleaning steps, the recovered pulp is mixed with additives to form a papermaking furnish which is fed into a paper machine to produce recycled paper.

Methodology
Process Flow



Please refer to the full document 'CEPI Harmonised European Laboratory Test Method (Part 1)' for further details on how your testing is carried out within the DS Smith RES laboratory.

This Recyclability Evaluation Service adheres to Version 3 of the CEPI 4EG Harmonised Recyclability Testing Methodology.

Results Breakdown

Paper Bag with Plastic Inner Liner

Sample Preparation

SAMPLE FRONT

Sample Description

The sample consisted of a Paper Bag with Plastic Inner Liner.

Please note – the recyclability score applies to the packaging product in its given state when tested. If you choose to test a concept/semi-finished sample, adding inks or adhesives at a later stage in development/production may affect the recyclability score.

SAMPLE BACK

Preparation Method

Preparation of the sample was carried out as shown in the Recyclability Methodology under 'Standard sample preparation'.

53.02g *(50 g oven-dry equivalent)* of material was cut into 3x3cm pieces, ready for disintegration.

The average **dry content** of the product was calculated from the individual components.

Calculated average dry content = **97.52%**

SAMPLE COMPONENTS (IF APPLICABLE)

Further Observation

Further observations on anything else during sample prep which may impact the test results – e.g. insufficient sample amount/no further observations.

Results Breakdown

Paper Bag with Plastic Inner Liner

Disintegration , Filtrate Analysis and Determination of Evaporation Residue

Disintegration

Tap water (at 40˚C and pH 7) was added to the prepared sample to achieve a stock consistency of 2.5%.

This was disintegrated for 10 minutes (30,000 revolutions).

The sample managed to disintegrate completely with plastic lining partially disintegrated .

The disintegrator stopped at the beginning of the process. Experienced high strain during restarted operation.

Filtrate Analysis and Determination of Evaporation Residue

Filtrate Analysis was carried out as per the 4EG Recyclability Methodology.

There was a clear tint and low opacity to the filtrate (pictured left).

This analysis was carried out twice for the filtrate and twice for tap water.

The Evaporation Residue was calculated as follows:

Evaporation Residue g/g	0.00049
Evaporation Residue of the sample mg/g	6.44
Evaporation Residue of the product %	**0.64%**

Results Breakdown

Paper Bag with Plastic Inner Liner

Chemical Oxygen Demand of Wastewater Evaluation

A double determination of wastewater extract characteristics, through further analysis of the filtrate from the initially disintegrated material, was collected and each was assessed for **Chemical Oxygen Demand (COD)**. This helps assess the potential impact of the pulped material on wastewater quality.

A tap water reference was run as standard, but in cases where it fell below the detection limit of the analytical system, a zero-value was assumed.

For packaging, COD has a threshold value of 60 mgO_2/g, while the target is 25 mg/g or below. Low values are preferable.

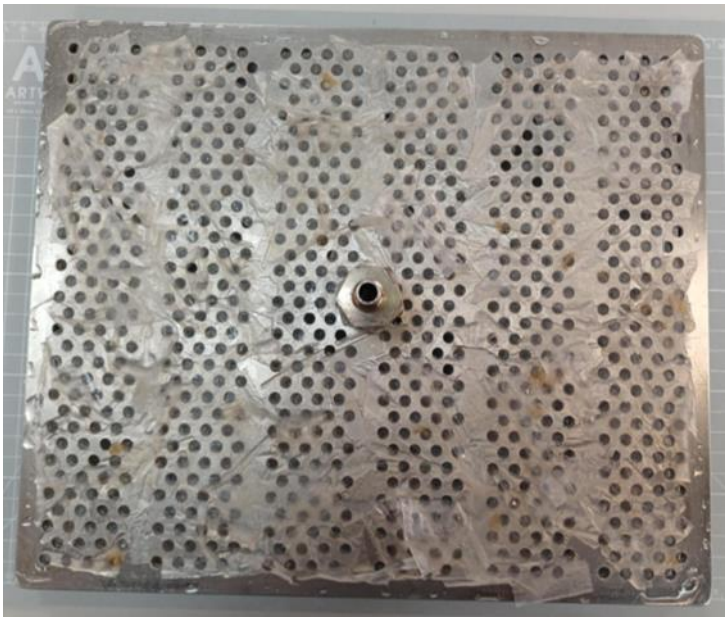
COD - Determination		
Dilution	1	1
COD-Test + Measurement range [mg/l]	0-10,000	0-10,000
Measured values [mg/l]	563.3	42.1
Weight air-dried [g]	53	53
Fiber quantity oven-dried [g/l]	25.84	25.84
COD related to 1 kg of product [g/kg]	0.16	0.16
COD related to 1 kg of product [%]	21.80	1.63
Mean COD related to 1 kg of product [%]	**11.71**	

This sample COD value was **below** the target level and **below** the threshold levels.

Results Breakdown

Paper Bag with Plastic Inner Liner

Coarse Screening



The Sommerville fractionator was fitted with the 5 mm perforated plate.

The entire repulped sample was added, and processed for 5 minutes, with all of the accept material collected.

The rejects collected on the plate (pictured left) were transferred to a foil dish and dried.

Coarse Reject (including dry removed components) Related to total Product = **4.76%**

Description of Coarse Screening Reject	General Impression
Are there fibre specks in the reject?	Yes
If yes, how much?	Few
In which type / size?	Small
Are non-paper product components in the reject?	Yes
If yes, how much?	Many
In which type/size?	Large
How is the integration grade of the particles?	Partly Disintegrated
Out of which material consists the non-paper component?	Plastic Film

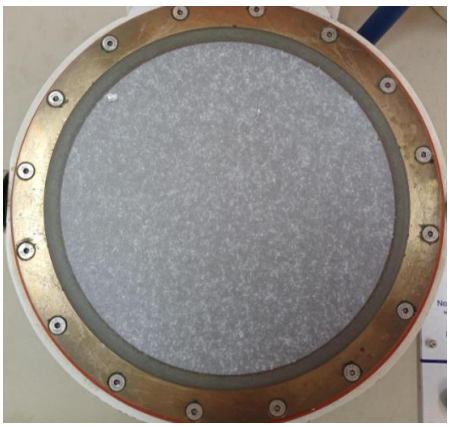
Close-up image of reject components.

Results Breakdown

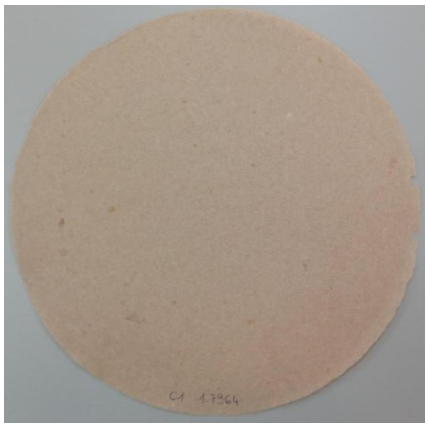
Paper Bag with Plastic Inner Liner

Coarse Accept Visual Impurities Evaluation

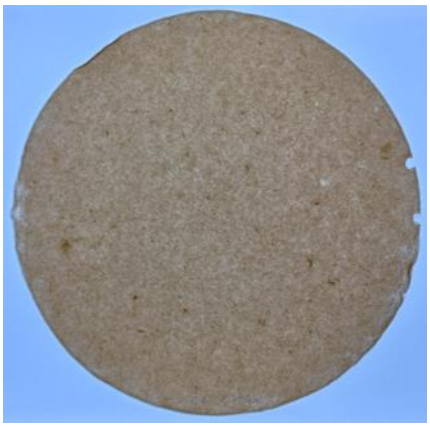
Two lab sheets were made with the fine accepts material collected from the coarse screening, and each was assessed for visual impurities.



Wet Formation Sheet



Dry Sheet



Sheet with Back Light

Visual Assessment of the Coarse Accept	Sheet 1 Assessment	Sheet 1 Rating	Sheet 2 Assessment	Sheet 2 Rating
No Visual Impurities	-	-	-	-
Wax Stains	-	-	-	-
Metallised Particles	-	-	-	-
Translucent Particles	-	-	-	-
Colour Shading	Light	Level 1	Light	Level 1
Ink and Varnish Particles	-	-	-	-
Pigment Coating Particles	Some, big	Level 2	Some, big	Level 2
Fibres/fibre flakes	Many	Level 2	Many	Level 2
Others	-	-	-	-
Evaluation	Level 2		Level 2	
Overall Evaluation	**Level 2**			

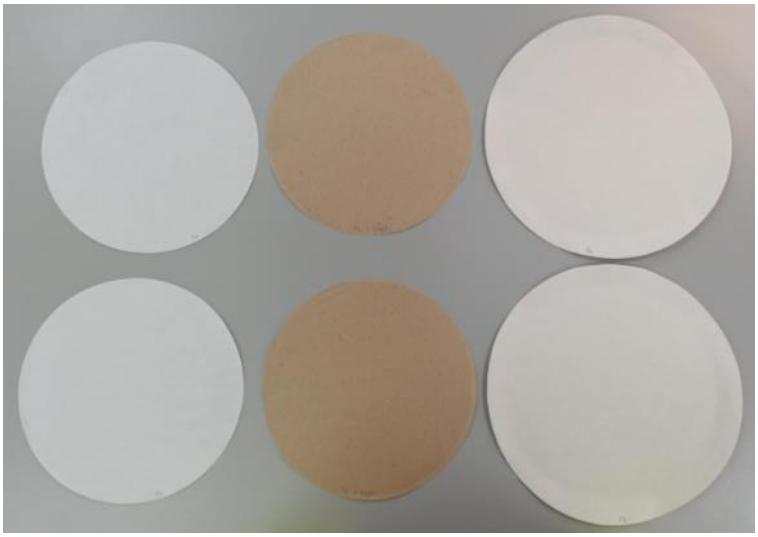
Results Breakdown

Paper Bag with Plastic Inner Liner

Coarse Accept Sheet Adhesion Evaluation

Two lab sheets were made with the coarse accepts material collected from the fine screening, and each was assessed for sheet adhesion.

Sheet Adhesion Evaluation of Coarse Accepts	Sheet 1 Assessment	Sheet 2 Assessment
Damages/breakages	Absent	Absent
Fibres on support/cover	Absent	Absent
Fragments of paper on support/cover	Absent	Absent
Overall Evaluation	**Level 1**	



Left to right: Cover sheet, handsheet, cover board

Cover board under oblique light

Results Breakdown

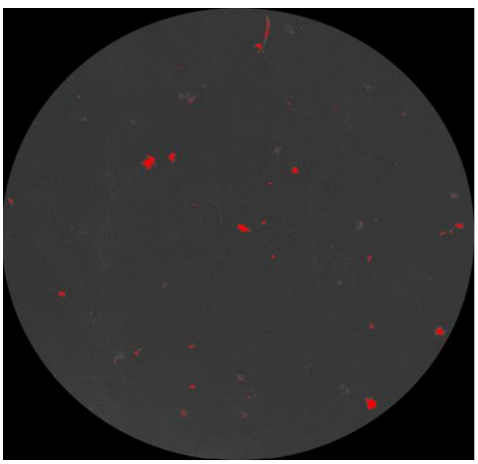
Paper Bag with Plastic Inner Liner

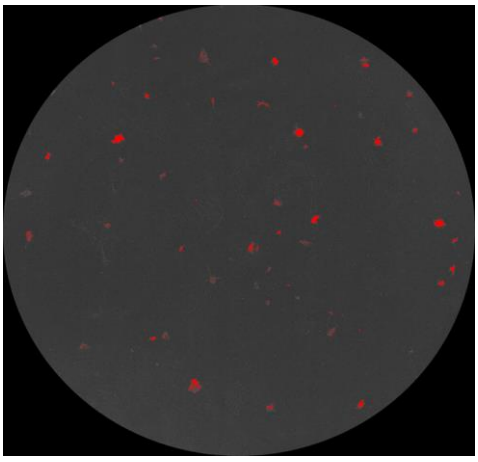
Macrosticky Evaluation of Coarse Accept-Fine Rejects (Particle Sizes 0.15 – 2 mm)

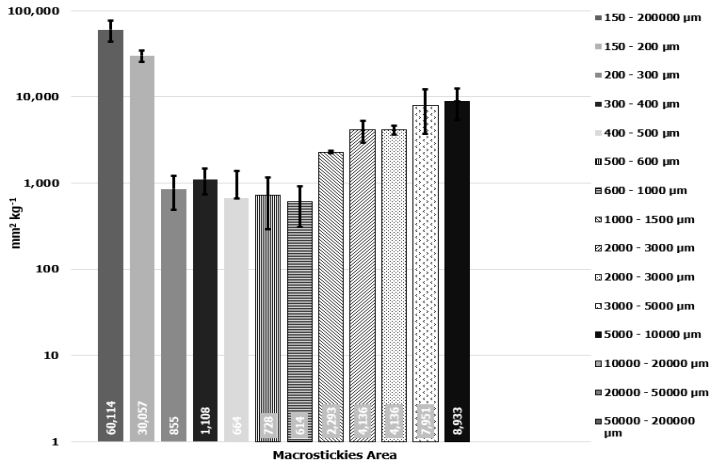
A double determination of the macrosticky components (i.e., tacky adhesives, waxes, inks, etc., between 0.15 – 2 mm size) was made in accordance with ISO 15360-2, to quantitatively analyse the number and area (mm² macrostickies area / kg of the sample as-is) of the particles. The method does not address microstickies. Coarse screening accepts were fine screened to isolate particles of the desired range.

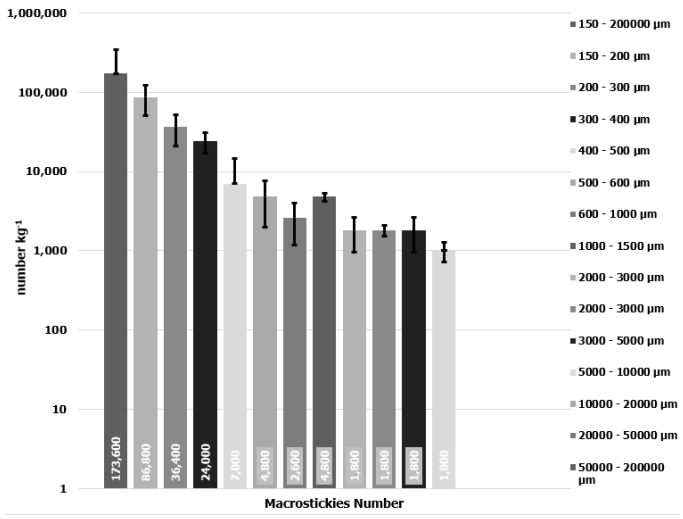
A high-definition image analysis software (*PTS-DOMAS multispec*) was used to measure the amount and size distribution of the adhesive particles across duplicate samples.

Log values of the distributions for the two duplicates are given in the graphs below, firstly as a sum across the entire analysis range, and then across the different size classes.









Results Breakdown

Paper Bag with Plastic Inner Liner

Macrosticky Evaluation of Coarse Accept-Fine Rejects (Particle Sizes 0.15 - 2 mm)

Total areas of Macrostickies (150 - 200,000 µm): **60,114 mm²/kg**

Area of Macrostickies with Equivalent Diameter ≤2,000 µm: **39,095 mm²/kg**

Macrostickies Values	Mean (mm²/kg)	± (mm²/kg)
Total macrostickies area 150 - 200000 (µm)	60,114	16,235
Area Iso 150 - 200 (µm)	30,057	4620
Area Iso 200 - 300 (µm)	855	364
Area Iso 300 - 400 (µm)	1,108	361
Area Iso 400 - 500 (µm)	664	711
Area Iso 500 - 600 (µm)	728	435
Area Iso 600 – 1,000 (µm)	614	300
Area Iso 1,000 – 1,500 (µm)	2,293	63
Area Iso 1,500 – 2,000 (µm)	2,775	1160
Area Iso 2,000 – 3,000 (µm)	4,136	484
Area Iso 3,000 – 5,000 (µm)	7,951	4238
Area Iso 5,000 – 10,000 (µm)	8,933	3492
Area Iso 10,000 – 20,000 (µm)	0	0
Area Iso 20,000 – 50,000 (µm)	0	0
Area Iso 50,000 – 200,000 (µm)	0	0

Results Breakdown

Paper Bag with Plastic Inner Liner

Fine Screening

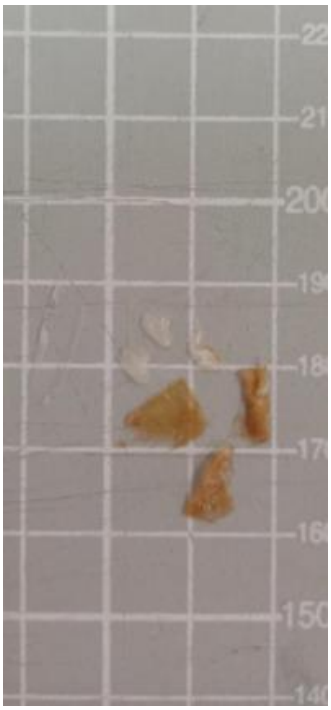
The Sommerville fractionator was fitted with the 0.15 mm slotted screen.

The equivalent of 20 g oven-dry sample was added and processed for 20 minutes, with the first 50 L of accept material collected.

The rejects collected on the plate (pictured left) were transferred to a foil dish and dried.

Fine Reject Related to total Product = **0.62%**

Description of Fine Screening Reject	General Impression
Are there fiber specks in the reject?	Yes
If yes, how much?	Yes
In which type / size?	Many
Are non-paper product components in the reject?	Small
If yes, how much?	Yes
In which type/size?	Few
How is the integration grade of the particles?	Small
Out of which material consists the non-paper component?	Partially disintegrated



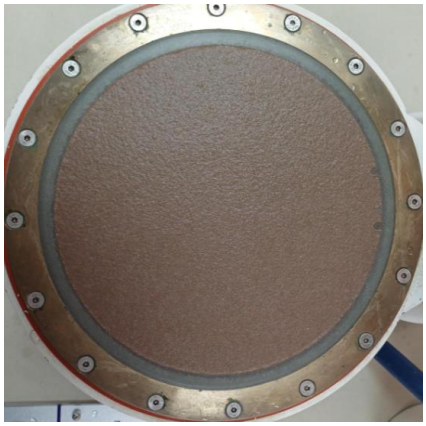
Above: Close-up detail of fine reject components.

Results Breakdown

Paper Bag with Plastic Inner Liner

Fine Accept Visual Impurities Evaluation

Two lab sheets were made with the fine accepts material collected from the fine screening, and each was assessed for visual impurities.



Wet Formation Sheet

Dry Sheet

Sheet with Back Light

Visual Assessment of the Fine Accept	Sheet 1 Assessment	Sheet 1 Rating	Sheet 2 Assessment	Sheet 2 Rating
No Visual Impurities	-	-	-	-
Wax Stains	-	-	-	-
Metallised Particles	-	-	-	-
Translucent Particles	-	-	-	-
Colour Shading	Light	Level 1	Light	Level 1
Ink and Varnish Particles	-	-	-	-
Pigment Coating Particles	-	-	-	-
Fibres/fibre flakes	Few	Level 1	Few	Level 1
Others	Few, small	Level 1	-	-
Evaluation	Level 1		Level 1	
Overall Evaluation	**Level 1**			

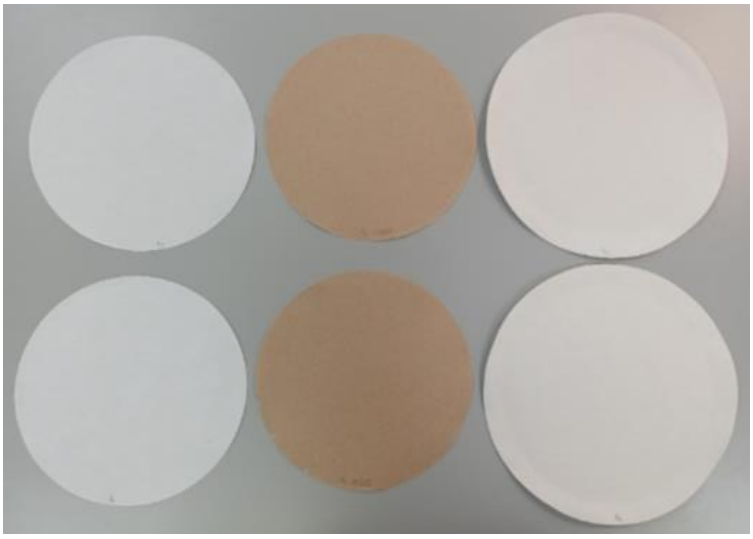
Results Breakdown

Paper Bag with Plastic Inner Liner

Fine Accept Sheet Adhesion Evaluation

Two lab sheets were made with the fine accepts material collected from the fine screening, and each was assessed for sheet adhesion.

Sheet Adhesion Evaluation of Fine Accepts	Sheet 1 Assessment	Sheet 2 Assessment
Damages/breakages	Absent	Absent
Fibres on support/cover	Absent	Absent
Fragments of paper on support/cover	Absent	Absent
Overall Evaluation	**Level 1**	



Left to right: Cover sheet, handsheet, cover board

Cover board under oblique light

Scorecard

Paper Bag with Plastic Inner Liner

INPUT PARAMETER	UNIT OF MEASUREMENT	INPUT VALUE	POSSIBLE SCORE RANGE	SCORE
Disintegration Time	Minutes	10		
Coarse Reject	0 - 100 [%]	4.8		
Fine Reject	0 - 100 [%]	0.6		
Total Screening Yield	0 - 100 [%]	94.7	min = -100, max = +100	89
Evaporation Residue	mg/g packaging	6.44	min = -200, max = 0	0
Visual Impurities	1-4 [Level]	1	min = KO, max = 0	0
Sheet Adhesion	1-3 [Level]	1	min = -30, max = 0	0
Technical Recyclability Score		**Technically recyclable in a recycling mill with conventional process.**	min = -100, max = +100	89

This scorecard was generated in line with the 4evergreen Fibre-Based Packaging Recyclability Evaluation Protocol.

Any sample with a Technical Recyclability Score of <0 is not deemed suitable for a Recycling Mill with Conventional Process but may potentially be recyclable in other mill types.

The CEPI Harmonised Testing Methodology and 4evergreen Recyclability Evaluation Protocol is designed to evaluate the recyclability of an unused/pre-consumer packaging product.

As well as testing the actual material(s) which comprise a packaging product, it is also important to consider its intended use-case/contents.

Regardless of test score, the acceptance of products for recycling is at the discretion of the mill. E.g. a a product containing prohibitive materials may be rejected by a recycling mill with conventional process, despite a positive score when tested against the CEPI 4EG procedure.

Scorecard

Paper Bag with Plastic Inner Liner

Yield

Yield	
Score	**Description**
90-100	The packaging creates a **high screening yield** in a recycling mill with conventional process.
70-89	The packaging creates an **acceptable screening yield**, but the rejects could already have an impact in a recycling mill with conventional process.
50-69	The packaging creates a **poor screening yield** a recycling mill with conventional process, and it is suggested that the packaging should be further optimised for recycling.
0-49	The packaging creates a **very poor screening yield** which can lead to technical problems in the screening step in a recycling mill with conventional process.
<0	The packaging creates an **unacceptable screening yield** for the recycling process in a recycling mill with conventional process and should not be recycled in such process.

This packaging product had a **Coarse Reject percentage of 4.76%,** a **Fine Reject percentage of 0.62%** and has an overall yield of **94.7%**, corresponding to a score of **89**.

This Recyclability Score indicates the packaging creates an acceptable screening yield, but the rejects could already have an impact in a recycling mill with conventional process.

Scorecard

Paper Bag with Plastic Inner Liner

Dissolved and Colloidal Substance

Dissolved and Colloidal Substance (DCS)	
Score	**Description**
0 to -3	DCS expected to pose **negligible issues** in the process of a recycling mill with conventional process.
-3 to -45	DCS expected to have **minor issues** in the process of a recycling mill with conventional process.
-45 to -100	DCS expected to **have issues** in the process of a recycling mill with conventional process and suggest further optimisation.
< -100	DCS expected to have **major issues** in the process of a recycling mill with conventional process . It is recommended to test this product with part III testing in future FBCP process.

This packaging product has been given a **Dissolved and Colloidal Substance (DCS)** score of 0 resulting from 6.44 mg/g packaging.

For packaging, a threshold 50 mg/g or below is desirable, with a threshold of up to 100 mg/g being acceptable. This sample value was **below** both the **threshold** and **target** levels

DCS expected to pose negligible issues in the process of a recycling mill with conventional process.

Scorecard

Paper Bag with Plastic Inner Liner

Visual Impurities

Visual Impurities		
Level	**Score**	**Description**
Level 1	0	Poses **no** visual quality issues.
Level 2	-5	Poses **minor** visual quality issues.
Level 3	-15	Poses **noticeable** visual quality issues.
Level 4	-30	Poses **significant** visual quality issues.

This packaging product has been given a **Visual Impurities** rating of **Level 2,** correlating to a score of **-5.** This was determined from the fine accepts lab sheets.

This means the packaging poses minor visual quality issues that can be acceptable in the mix.

Scorecard

Paper Bag with Plastic Inner Liner

Sheet Adhesion

Sheet Adhesion		
Level	**Score**	**Description**
Level 1	0	Poses **no adhesion issues**.
Level 2	0	Poses **minor adhesion issues** that can be acceptable in the mix.
Level 3	KO	Poses **significant adhesion issues** that can have a significant impact on a recycling mill with conventional process and is therefore not considered recyclable.

This packaging product has been given a **Sheet Adhesion** rating of **Level 1,** correlating to a score of **0**.

No sheet adhesion was noticed in the coarse accepts lab sheets. No sheet adhesion was/was not noticed in the fine accepts lab sheets.

This means the packaging poses no adhesion issues.

Evaluation Summary

Paper Bag with Plastic Inner Liner

INPUT PARAMETER	POSSIBLE SCORE RANGE	SCORE	COMMENTS
Total Screening Yield	min = -100, max = +100	94.7%	The packaging creates a high screening yield in a recycling mill with conventional process.
Evaporation Residue	min = -200, max = 0	6.44mg/g packaging	DCS expected to pose negligible issues in the process of a recycling mill with conventional process.
Visual Impurities	min = K0, max = 0	1	This means the packaging poses no adhesion issues.
Sheet Adhesion	min = -30, max = 0	1	This means the packaging poses minor visual quality issues that can be acceptable in the mix.
Technical Recyclability Score	**min = -100, max = +100**	**89**	This sample was determined as **Suitable for Standard Mill recycling.**

This scorecard was generated in line with the 4evergreen Fibre-Based Packaging Recyclability Evaluation Protocol.

Any sample with a Technical Recyclability Score of <0 is not deemed suitable for a Recycling Mill with Conventional Process, but may potentially be recyclable in other mill types.

The CEPI Harmonised Testing Methodology and 4evergreen Recyclability Evaluation Protocol is designed to evaluate the recyclability of an unused/pre-consumer packaging product.

As well as testing the actual material(s) which comprise a packaging product, it is also important to consider its intended use-case/contents.

Regardless of test score, the acceptance of products for recycling is at the discretion of the mill. E.g. a a product containing prohibitive materials may be rejected by a recycling mill with conventional process, despite a positive score when tested against the CEPI 4EG procedure.

SAMPLE FRONT

SAMPLE BACK

Post-Testing Consultation Services

Optional Add-On

DS Smith also has the capability to offer **post-testing consultation services**. This is an optional add-on for customers of our RES testing service.

A consultation session with our DS Smith Recyclability Laboratory Technician allows us to talk you through a step-by-step interpretation of your RES test results and report. This can be extremely beneficial in allowing you to correctly apprehend the testing stages and results included within this report.

If you are interested in receiving a consultation, please contact your RES Account Manager. Alternatively, email our RES Sales Team at **recyclability.sales@dssmith.com**

Appendix
Sample Preparation Detail

SIMPLE/COMPLEX SAMPLE PREPERATION:

During the initial sample preparation phase, a packaging product will be categorised as either a 'simple sample material' or 'complex sample material'. Simple samples are those which are semi-finished products, are flat and do not have different components. Complex samples are those that are 3D and include multiple components.

The 4evergreen annex documents for Part 1 – Recycling Mill with Conventional Process, details the work description for the necessary laboratory procedures for the preparation of sample material to be analysed according to the CEPI methodology. This contains a detailed procedure for preparing simple and complex sample materials, complex sample preparation methodology provides details additional to this on how different 3D or multi-component packaging products should be prepared for accurate testing purposes.

Simple sample preparation involves the following steps:

1. Dry content determination
2. Cutting the specimen
3. Ageing
4. Documentation in Excel

AGING OF SAMPLE:

All samples submitted should be more than 15 days post-production. Wet strength-containing samples should be no older than 30 days post-production.

If the sample contains wet strength agents and was produced less than 30 days ago, it is stored for the time needed to complete this ageing. Another option is to perform accelerated ageing by placing the sample in the oven at (60 ± 1) °C for 72 hours.

In case of samples without wet strength agent, make sure the sample is at least 15 days old from the date of production, and therefore no ageing is necessary.

Appendix

Results Determination: Technical Recyclability Score

In order to calculate the technical recyclability score, several output values of the lab test are considered.

The table below shows the output values currently being considered within the 4evergreen Recyclability Evaluation Protocol. A detailed explanation of how these values are obtained can be found in the description of the CEPI Harmonised Testing Methodology.

In order to translate the output values into one final Technical Recyclability Score, the results of the following parameters are added: Total Screening Yield, Dissolved and Colloidal Substances, Visual Impurities, and Sheet Adhesion.

Parameter	Acronym	Meaning
Coarse Reject	**CR**	Weight percent of packaging retained by coarse screening and dry removed components.
Fine Reject	**FR**	Weight percent of packaging retained by fine screening after coarse screening.
Total Screening Reject	**TSR**	Sum of coarse and fine reject, using a correction factor for the fine screening reject value.
Total Screening Yield	**TSY**	Total amount of packaging minus TSR expressed in percent.
Dissolved and Colloidal Substances	**DCS**	Mass of substances in the filtrate obtained following filtration of pulp and disintegration related to packaging mass in mg/g (determined as evaporation residue, ER).
Visual Impurities	**VI**	Evaluation of the pulp's optical appearance, evaluated at a handsheet remaining after fine screening accept.
Sheet Adhesion	**SA**	Evaluation of the tackiness of a hand sheet from fine screening accept.
Disintegration Time	**DT**	In general, the disintegration time is 10 min If at least 15% of total screening rejects is measured, containing a significant amount of fibres, and there is no knockout for sheet adhesion, the time can be extended to 20 min
Reject Characterisation	**RC**	Description of the main components of the reject. Characterisation of coarse and fine reject is needed for assessing 'significant amount of fibres' (20 min disintegration option) and two-side water barrier coating.

Text on this page was taken from: 4EVERGREEN FIBRE-BASED PACKAGING RECYCLABILITY EVALUATION PROTOCOL VERSION 1, JAN 2025

Appendix

Results Determination: Total Screening Yield

The Total Screening Reject (TRS) is calculated according to the equation shown below on the left. The total screening reject measures how much solid material is removed by screening.

All terms used in Equation 1 can be found in the table on the previous page, except for α which is a correction factor used to mimic the solid material recovery in multi-stage screening processes. Residence times and mechanical shearing forces applied in the industrial process – for example in pumps – can trigger a slightly better disintegration of fibre bundles compared to lab conditions. The value of α is set to 0.9 based on expert consensus. The constant α might be changed into a variable value taking the fine reject characterisation into account in future versions.

$$TSR = CR + FR * \alpha$$

where

- TSR is the Total Screening Reject (%);
- CR is the Coarse Reject rate (%);
- FR is the Fine Reject rate (%);
- α is the correction factor.

Complementary to the Total Screening Reject (TSR) is the Total Screening Yield (TSY), which - beside the Evaporation Residue (ER) -describes the amount of material mass that can be reused in a new fibre product. The calculation is shown in Equation 2.

$$TSY = 100\% - TSR$$

where

- TSY is the Total Screening Yield;
- TSR is the Total Screening Rejects.

For a recycling mill with conventional process striving for high yield, the TSR amount must be kept to a minimum. This has clear financial, technical and environmental benefits reflected in the score level allocated. The calculation for the yield score is shown in Table 4 and is divided into five intervals or ranges. Each interval indicates an increasing reduction in score as the yield becomes lower and less material can be recovered. A value of 0 is reached at 80% yield or 20% total screening TSR. A visual representation of the score intervals as a function of yield is shown in Figure 3. As fewer points are lost when reject amounts are lower, a greater error percentage in the results in lower yield ranges ensures the scoring is still reliable.

Appendix

Results Determination: Dissolved and Colloidal Substances

The Dissolved and Colloidal Substances (DCS) score reflects an assessment of the amount of material that would be lost in the filtrates during recycling. Although some effluents could be considered for (bio)gas production it is considered that an excess of this type of substance would be disturbing in the recycling process.

DCS are derived directly from the Evaporation Residue in milligram solids per gram of packaging which is a direct result of the CEPI Harmonised Testing Methodology.

The evaporation residue (ER) is obtained by filtering the pulp immediately after the disintegration and volatilising the obtained filtrate until reaching a constant mass. The filtering is done via a paper filter so that only DCS and some very small particles like minerals remain in the filtrate, all of which are considered in the final score.

This residue is not considered as recyclable material. A value of e.g. 50 mg/g DCS indicates that 5% of the packaging ended up in the filtrate as DCS.

The DCS score is calculated directly from the ER lab result. Similar to the yield score, the DCS penalty becomes progressively more negative as DCS levels increase. Five intervals are considered based on the DCS value, as shown in the table below.

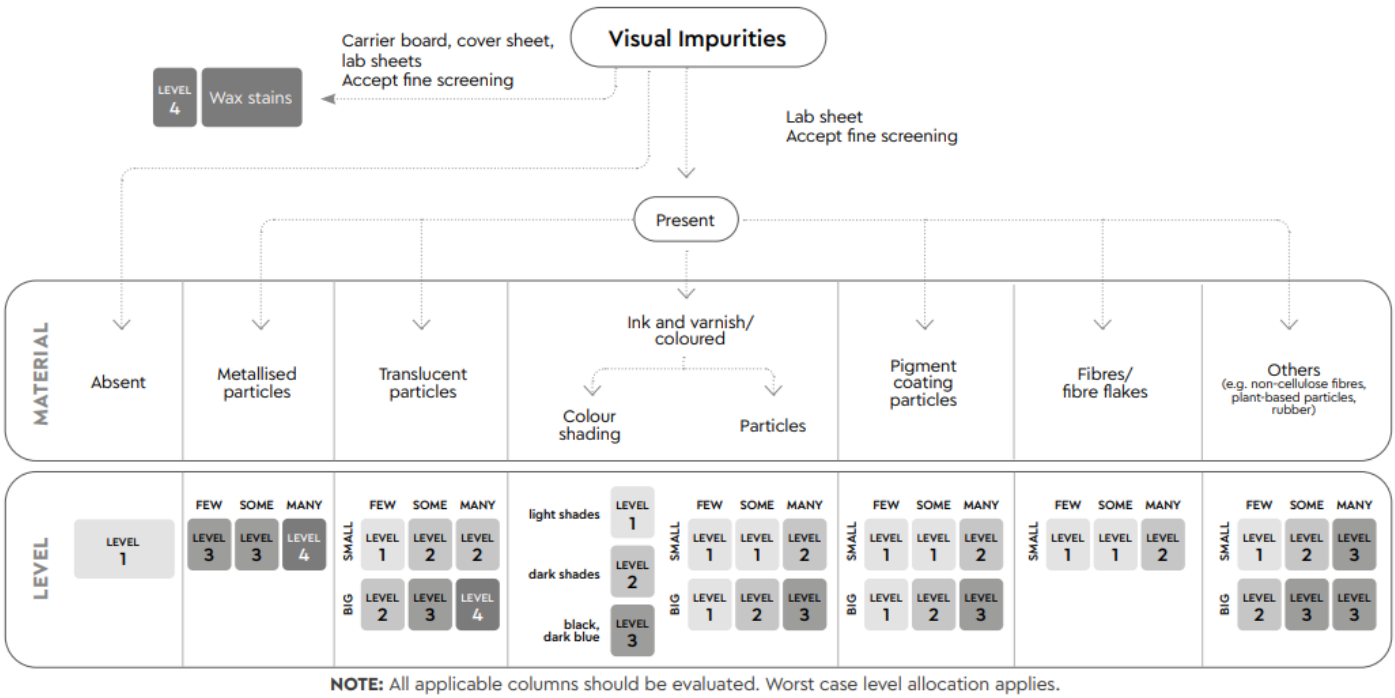
DCS (mg/g packaging)	Formula	DCS Score
≤50	Score=-DCS * 0.05	0...-3
50...150	Score=-2,5-(DCS-50) * 0,525	-3...-45
150...200	Score=-55-(DCS-150) * 0,9	-45...-100
200...311	Score=-55-(DCS-150) * 0,9	-100...-200
≥311	Score = -200	-200

Appendix

Results Determination: Visual Impurities

For the visual impurities, a qualitative and quantitative evaluation is described in the test method, as shown in the decision below which converts the assessment into levels from 1 to 4.

Each level defines a range of visual impurities observed in the pulp, where Level 1 is considered to have no visual quality issues and Level 4 shows significant issues impacting the optical quality of the pulp.



NOTE: All applicable columns should be evaluated. Worst case level allocation applies.

LEVEL 1 No visual quality issues
LEVEL 2 Minor visual quality issues
LEVEL 3 Some visual quality issues
LEVEL 4 Significant visual quality issues

Visual impurities per hand sheet

Average Amount/ Handsheet	Few	Some	Many
	<10	10 - 100	>100
Size (1dimension)	Small	Big	Combination
	=<1 mm	>1 mm	Consider the worst case level

Figure 7. Decision tree to evaluate the level of the visual impurities

Appendix

Results Determination: Sheet Adhesion

Similarly to visual impurities, sheet adhesion is a qualitative evaluation that is assigned to three possible levels, and described in detail in the test method. Level 1 indicates no adhesion issues are observed when using the recovered material. Level 2 is assigned to material that shows sheet adhesion but only up to a degree which likely has a limited impact on the production process. Lastly, Level 3 is assigned when sheet adhesion Is clearly observed and the recovered material would likely lead to production problems.

Given the severity of Level 3, it is considered a knockout factor and the total score is immediately set to a negative value, making the tested product not technically recyclable in a recycling mill with conventional process. The test method provides details and examples for the level assignment. Water soluble tacky materials might not be detected with the sheet adhesion method.

In the table below, sheet adhesion levels are given a final score. As can be seen no points are lost or gained when Level 1 and 2 are observed. It was agreed based on expert consensus, that the Level 2 is not regarded as critical to be reflected as point reduction. However, Level 2 does alert the packaging designer that there is some sticky content in the final product.

Sheet adhesion level Score	Sheet adhesion Description	Visual Impurities Score
1	0	**Tackiness** absent: the hand sheet can be separated completely from the carrier board and cover sheet without any damage or breakage. A few single fibre pickups can be present on the carrier board and cover sheet. Visible damage to the hand sheets and fragments of paper on the carrier board and cover sheet are not permitted.
2	0	**Tackiness** partly present: the hand sheet can be separated completely from the carrier board and cover sheet. Fibre tears and particles occur on the carrier board, the cover sheet and the hand sheet itself.
3	Knockout	**Tackiness** present: the hand sheet cannot be separated from its carrier board and the cover sheet without visible damage to the hand sheet itself. A breaking of the hand sheet or holes (> 1mm [in two dimensions]) occur. **NOTE:** The rating must reflect all sheet adhesion tests conducted and provide an accurate representation of overall performance. A single occurrence of a defect may be disregarded if it is limited to an isolated hole and does not exhibit any fiber tears.