Short Report

FFI/PTS-Project „Recyclability of Folding Cartons and Material Combinations“
Investigations performed by PTS Papiertechnische Stiftung
October 2020

The present Short Report represents an overview of the “PTS Report on the FFI Project Recyclability of Folding Cartons (August 2020)” (full version) and is in terms of content and statement identical to the full version. Contrary to the full version the technical specifications of the model types of the investigation are not included in the Short Report. The publication of the Short Report – also in extracts - is explicitly welcome. Please cite the report as follows: „Short Report FFI/PTS-Project ‚Recyclability of Folding Cartons and Material Combinations‘ (October 2020)”

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1. Confirmed: Folding Cartons are recyclable through the recycling path of separate paper and board collection

Based on the assumption that the selected types of folding cartons are representative of packaging containers of consumer products for private end users, the study demonstrates that folding cartons are recyclable from within the paper stream collected from private households.

It could be shown for all of the analysed folding carton types that the entire fibre component can be recycled. As expected, the pulp yield is reduced by the amount of non-paper components only.

Varying disintegration times of 10 minutes or 20 minutes do not influence the pulp yield, for the pulp mostly being already disintegrated after an interval of 10 minutes. The entire fibre component can be recycled.

Regarding the quality of the extracted pulp, visually disturbing inhomogeneity and increased adhesiveness occurred on few model types of the feature groups Print & Varnish and Adhesive Applications. They can yet be separated and the extent in the paper stream collected from private households is not critical. The quality of the fibre so obtained (recyclate) therefore shows no limitation to mechanical recycling via the mixed paper stream collected from households.

Plastic components from inner coating or outer coating lamination fragment slightly were easily removable through separation, which shows that one sided coated folding cartons and cup materials that are coated one side only and have a fibre component without wet-strength treatment can be recycled in the mixed paper stream collected from households.

Metallized components from lamination with a metallized foil and metal pigmentation by cold foil transfer were less separable. The presence of fragmented metal particles in the accepts leads to conspicuous specks. In the mixed paper stream collected from households it is still considered as recyclable.

2. Background: Shareholders demand verification of recyclability through recovered paper process

The recycling of folding cartons as a sub-fraction of paper and board is established through the processes of collection, sorting and recovery of the stream of recovered paper for decades. Recovered paper is a resource with a market value, and the current recycling rates show the success of this approach. The circular use of the recyclate, the recycled fibre, is practiced sustainability.

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Those socio-political and environmental requirements in regard to the circular use of resources also for packaging production are increasingly addressing especially brand owners, retailers or distributing companies and disposal companies. The branded goods industry and the retailers respond to this challenge by defining principles and standards governing the recyclability of packaging and their required amount of recyclate. In addition to that, consumers are increasingly included in the process by directed information on the products about the disposal and separation of packaging. The legal requirements of informing the end-consumer about the correct separation and disposal of packaging waste also apply to the dual systems (in Germany). To fulfill those requirements they need specific recommendations and defined criteria regarding the allocation of packaging in the different systems of waste collection (specific waste paper bins, such as “blue bin” in Germany; mixed collection of light packaging, such as “yellow bag” in Germany, residual waste).

Product responsibility for the marketing of sales packaging in Germany is governed and concretized by the German Packaging Act (Verpackungsgesetz). Art. 21 (“Ecological structure of the participation fee”) of said act introduced recyclability requirements in 2019. Every year, on the first day of September, a so-called “minimum standard for determining the recyclability of packaging subject to system participation”[1] is published, which defines the minimum criteria according to which the recyclability is to be determined. According to Art. 21 of the German Packaging Act, the recyclability of packaging should be reflected in the determinations of the license fees by obligating the dual systems to provide financial incentives for highly recyclable material and material combinations and the use of the recyclate.

Against this background the question arises if and how the various material combinations and upgrading process influence the individual recyclability of folding cartons.

3. Motivation: Folding Carton industry demonstrates high competence in solution-finding

The results of the present study by FFI/PTS are providing for the first time both general and specific scientifically and technically robust findings about the recyclability of folding cartons for a well-founded representation of the interests of the industry based on the professional expertise in dialogue with authorities, supply chain partners and waste management stakeholders.

In addition, the individual FFI folding carton-company is supported to respond accordingly to their costumers’ requests concerning the individual packaging product. The results of the investigation

[1] Published by Central Agency Packaging Register (ZSVR) in agreement with the Federal Environment Agency (UBA); updated annually

enable the FFI member companies to classify their own packaging models and rate their recyclability. Therefore, the study is designed as a “type test” allowing FFI members to start out from a model type and draw inferences about a specific folding carton produced or to be produced according to customer order. Such inference should enable folding carton manufacturers to make a rough assessment of their product without having to run any tests on their own.

4. Investigation of cartons representative

Altogether 24 variants (including the evaluation of reference samples as unconverted cartonboard) to be tested for their recyclability on a laboratory scale.

The selected carton models were representative[2]:

a) In terms of market relevance the models were typical folding cartons from the food market segments (dry food, deep-frozen food, confectionery, tea/coffee, cereals) and non-food (cosmetics, pharmaceuticals).
b) Relevant variants were selected out of said segments and analyzed on the basis of various feature groups (such as print and varnish, outer and inner coating, and adhesive application, transparent windows) in terms of parameters impacting the mechanical recycling.
c) In each feature group common material types (conventional and low-migration offset-inks and dispersion varnishes, PE extrusion, lamination, et cetera) and average applied quantities, coating thickness and surface covering were selected.

[2] The statements apply to the recyclability of folding cartons in the recovered paper stream only concerning the selected model types, but not differing combinations beyond the followed design of investigation for example gravure- , flexo- and digital printing as well as screen printing varnish, sealing varnish, hotmelt adhesives, et cetera.

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5. Reliable results due to anticipation of the European Harmonised Method

The “minimum standard for determining the recyclability of packaging subject to system participation” of the ZSVR concerning the recyclability of packaging made of paper and board refer to the PTS-method (PTS-RH 021/97 [Version 2012]), which therefore is to be applied in investigations of folding cartons. Accordingly, this FFI investigation is based on said examination method.
Using this method an examination of the recyclability, the pulpability of the packaging material and the contamination by interfering materials is performed.

The lab-scale assessment of recyclability is based on the following criteria:

- Recyclable amount (quantity): Pulp yield
- Purity of the recyclate (quality): specks and stickies

In addition to the disintegration time of 20 minutes as defined in the method PTS-RH 021:2012, an additional reject test was performed after 10 minutes of disintegration, allowing the effect of the disintegration time to be estimated, in case a future harmonized European method should prescribe 10 minutes.

In the annex the applied methods of examination as well as the evaluation criteria can be found explained in detail.

6. Results of the individual material combinations

The specification of the model types follows the statements given by the manufacturer is documented in a project matrix. The model types were real-world folding carton packaging containers used in the market.

6.1 THE FEATURE GROUP PRINT&VARNISH SHOW ALMOST 100% OF RECYCLABLE COMPONENTS

Six model types in total were analyzed in the feature group print & varnish. For this purpose, different variations of printing inks (offset and UV) and varnishes (dispersion and UV) were selected.

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Table 1 Model types of the Print & Varnish feature group

Board	Ink	Varnish
GD	Offset FCM Ink compl.	Dispersion varnish FCM Ink compl.
GC	Offset FCM Ink compl.	Dispersion varnish FCM Ink compl.
GC	Offset FCM Ink compl.	UV varnish, gloss FCM Ink compl.
GZ	UV conv. part.	UV varnish, gloss conv. part.
GC	UV conv. part.	UV varnish, matt finish conv. part.
GC	Offset FCM Ink compl.	Dispersion varnish FCM Ink compl. + UV varnish FCM Ink part.

Abbreviations:
FCM Ink: Food Contact Material Ink = “low-migration“
conv.: conventional
compl.: complete surface
part.: partial surface

Key findings of the Print & Varnish feature group included that all analyzed model types of the Print & Varnish feature group are recyclable through the recycling path of separate paper and board collection within the household collection system. The entire fibre component can be recycled. There is maximum Pulp yield, the recyclable quantity is almost 100% (formally 99%) after a disintegration time of both 10 minutes and 20 minutes, therefore it is also shown that the time of disintegration time does not affect the amount of pulp yield.

Although inks and varnishes do not cause stickies, they form coloured particles (dirt specks) that cannot be separated. Those specks are variable in size, shape and colour, depending on packaging design/applied ink and varnish amounts, and are optically disturbing. Dispersion varnish, which is clear in most cases, tends to give fewer large specks in comparison with UV varnish which is typically coloured. Also larger area of UV varnish results in clearly larger speck areas with a higher percentage of large-sized specks while a larger area of UV prints in combination with UV varnish results in clearly larger speck areas and larger specks

Basically, the above described visually disturbing dirt specks (ink-varnish particles) and coating particles can be technologically reduced in size by the dispersion process so that they will no longer disturb the eye. Due to the process not being implemented or not operated in standard stock preparation lines in packaging paper production, further investments are necessary.

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6.2 MAXIMUM PULP YIELD ALSO IN FEATURE GROUP ADHESIVE APPLICATIONS

The model types in the second feature group were used to study the adhesive applications for side seam gluing (three model types) and window gluing (two model types). The formats were varied each time to ensure different dimensions in adhesive application and thus different adhesive areas in each of the cartons. The application methods for the adhesive are side seam gluing (disc gluing) and window gluing (cliché gluing). Each variation included a different amount of adhesive due to the varying dimensions of the cartons or windows. The final gluing of the folding carton with the packaged article inside was not analysed.

Table 2 Model types of the Adhesive Application feature group

Adhesive application	**Size**	**Adhesive**	**Type of application**
Side seam	Medium ‘Eurocube’ / Average relative application quantity	PVA dispersion adhesive	Disc
	Small (pharmaceuticals) / Large relative application quantity		
	Large (cereals) / Low relative application quantity		
Transparent window	Medium ‘Eurocube’ / Average relative application quantity		Cliché
	Large (cereals) / Low relative application quantity		

The key findings of the Adhesive Application feature group include that all analysed model types of the Adhesive feature group are considered recyclable through the recycling path of separate paper collection within the household collection system. There is maximum Pulp yield, the recyclable quantity, excluding the non-paper window component, is almost 100% (formally 99%). The entire fibre component can be recycled. The analysed samples showed uncritical amounts of gluing-induced stickies from window applications in the accepts, whereas this phenomenon cannot be observed for adhesive applications in the side seam. The varying glue application methods (disc gluing and cliché gluing) are considered a possible cause.

Furthermore the investigation showed that the amount of adhesives introduced through recovered paper is negligible for the evaluation of the carton. The reference cartonboard GD (recycled cartonboard, WLC) shows already minor levels of macrostickies, but they are not critical to the result.

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6.3 OUTER COATING DOES NOT REDUCE RECYCLABILITY

Reliable results[3] could be generated for two initial finishing methods selected for the Outer Coating feature group – lamination with a metallised foil and metal pigmentation by cold foil transfer.

Table 3 Model types of the Outer Coating feature group

Method	Material	Adhesive
Lamination	Metallised PET film, complete surface	Dispersion adhesive
Cold foil transfer	Metal pigments, partial surface	

As key finding of the Print & Varnish feature group it is to be mentioned that all analysed model types are recyclable through the recycling path of separate paper and board collection within the household collection system. Due to the use of non-paper components the recyclable amount of pulp is reduced to 92% respectively 88%. Varying disintegration times of 10 minutes or 20 minutes do not influence the pulp yield, for the pulp mostly being already disintegrated after an interval of 10 minutes. The entire fibre component can be recycled.

Fragmentation and thus separability of the PET film and the metal particles through slot screens is variable. While the PET film is not fragmented and completely separable, the particles of the cold foil are large enough for being separated in the screening step.

The dispersion adhesive applied across the entire surface causes a slight stickiness in the accepts, but its extent is not critical.

[3] In the course of the investigations it turned out that the specification of the model type regarding the hot stamping process was not suitable for generating reliable results. In a context of further research (also see chapter 7.1) applicable variants of the specifications of this method of application are to be determined.

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6.4 INNER COATING CARTONS RECYCLABLE

Three model types were analysed to compare different barrier layers. Selected were either an extrusion coating with PE or a foil lamination with PET film (metallised and non-metallised).

Table 4 Model types of the Inner Coating feature group

Coating method	**Material**	**Adhesive**
Extrusion	PE complete surface	none
Lamination	PET film complete surface	PE adhesive
	Metallised PET film complete surface	Dispersion adhesive

As key findings of the Inner Coating feature group it is to be mentioned that the analysed model types can be classified as recyclable as part of a household collection mix. Pulp yield is reduced by the non-paper components in the product which reduces the recyclable content by 91%, 93% and 92%. Varying disintegration times of 10 minutes or 20 minutes do not influence the pulp yield, for the pulp mostly being already disintegrated after an interval of 10 minutes. The entire fibre component can be recycled.

The plastic parts from PE extrusion coating and PET lamination show slight fragmentation but can be readily separated in slot screening. Fragmentation of the metallisation results in lower separability of the metallisation particles in slot screening. The fragmented metal particles in the accepts result in conspicuous specks but can be classified as recyclable as part of a household collection mix.

The dispersion adhesive does not induce any stickiness in the accepts. In contrast, the PE adhesive causes stickies in the accepts of the sample.

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6.5 EXCURSUS: CUP MATERIAL ALSO RECYCLABLE

In cooperation with PRO-S-PACK, German Food-Service Packaging Associaton (Arbeitsgemeinschaft für Serviceverpackungen), a further feature group including four model types of basic material for cup manufacturing. The disintegration behaviour of cup materials indicates that part of the fibre is discharged with the rejects when treated in standard stock preparation facilities, especially in case of products that are coated both sides. Typically, cups are not collected through separate paper collection and thus are not treated in standard facilities. Regarding the fact, that the structure of carton with inner coating and the structure of cup material coated one side only is nearly identical, it was of greater interest to identify and analyse similarities and differences of those materials in terms of recyclability.

Table 5 Model types of the Cup Material feature group

Coating method		**Material**
Extrusion	Inside complete surface, offline	PE
		Mineral-enriched PE
	Inside and outside complete surface, offline	PE
Varnish	Inside complete surface, application in board machine	Dispersion varnish

As key findings of the Cup Material feature group it is to be mentioned that all cup materials can be classified as recyclable as part of a household collection mix and that cup material which is coated one side only and have a fibre component without wet-strength treatment can even be recycled in standard stock preparation lines. The disintegration of the fibre material of the samples coated one side remains largely unaffected. Samples coated both sides show a significant deterioration of their repulping ability so the cup material samples show different defibration behaviours. Pulp yield is reduced by the non-paper components in the product, and this reduces the recyclable content (after 20 minutes: 94%, 92%, 84% and 89%).

In addition, the duration of disintegration has a statistically significant influence on the fibre yield (here; after 10 min: 92 %, 86 %, 67 %, 86 %) and thus on the reject quantity, which indicates that possibly part of the fibre is discharged in the reject; this applies in particular to products coated on both sides.

The model types with dispersion varnish (barrier) applications show strong fragmentation which yet can be separated.

7. Further Investigation Necessary

7.1 MORE IN-DEPTH INVESTIGATIONS FOR EXISTING MATERIAL FEATURE GROUPS

The investigation showed that there is a need of further investigation especially concerning the interaction mechanisms between varnish and inks which should be analysed with regard to speck formation, deinkability and the impact of the dispersion varnish and the interaction mechanisms between the surface coat and the ink. The behaviour of metal pigments in terms of fragmentation and screening, in particular for the application by hot stamping process, require further investigation as well.

7.2 FURTHER MATERIAL FEATURE GROUPS

Furthermore, research interests concern other application methods and combinations of materials, which were so far not investigated. This includes for example inks of gravure- , flexo- and digital printing as well as screen printing varnish, sealing varnish, hotmelt adhesives, et cetera. Those further and concretizing investigations of the presented feature groups will contribute to complete the overall picture of the recyclability of carton and its varying material combinations.

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8. Annex

8.1 TEST METHODS AND EVALUATION CRITERIA

The method PTS-RH 021:2012 Cat. II was used as a basic method for the testing of recyclability. The material was defibrated in a standard laboratory disintegrator according to DIN EN ISO 5263. Pulp yield was tested by determining the 0.7-mm hole screen[4] reject after disintegration. The purity of the recyclate was evaluated by forming a hand sheet from the fibrous material before and after screening with a 150-µm slot screen. The hand sheets were subjected to a sheet gluing test for the determination of stickies and to a visual examination for optical inhomogeneity.

In addition to the disintegration time of 20 minutes as defined in the method PTS-RH 021:2012, an additional reject test was performed after 10 minutes of disintegration, allowing the effect of the disintegration time to be estimated, in case a future harmonised European method should prescribe 10 minutes.

In order to quantify the optical disturbance potential, some of the specimens were subjected to an imaging analysis for measuring the dirt specks by means of DOMAS according to INGEDE Method 02[5]. In addition to that, INGEDE Method 04[6] was performed after a disintegration time of 10 minutes (similar to the Italian method UNI 11743:2019[7]) for the quantification of macrostickies. Since it was not always possible for methodological reasons to perform an analysis according to INGEDE Method 04, some of the specimens were characterised by means of NIR spectroscopy[8].

[4] Zellcheming Method ZM V/18/62 Gravimetric Determination of Flake Content in Fibre Suspensions
[5] https://www.ingede.com/ingindxe/methods/ingede-method-02-2014.pdf
[6] https://www.ingede.com/ingindxe/methods/ingede-method-04-2013.pdf
[7] UNI 11743:2019. Determination of parameters of recyclability of cellulose-based materials and products
[8] https://www.ptspaper.de/fileadmin/PTS/PTSPAPER/01_Ueber_uns/Dokumente/Veroeffentlichungen/2018_WBP_2_Makrostickys.pdf

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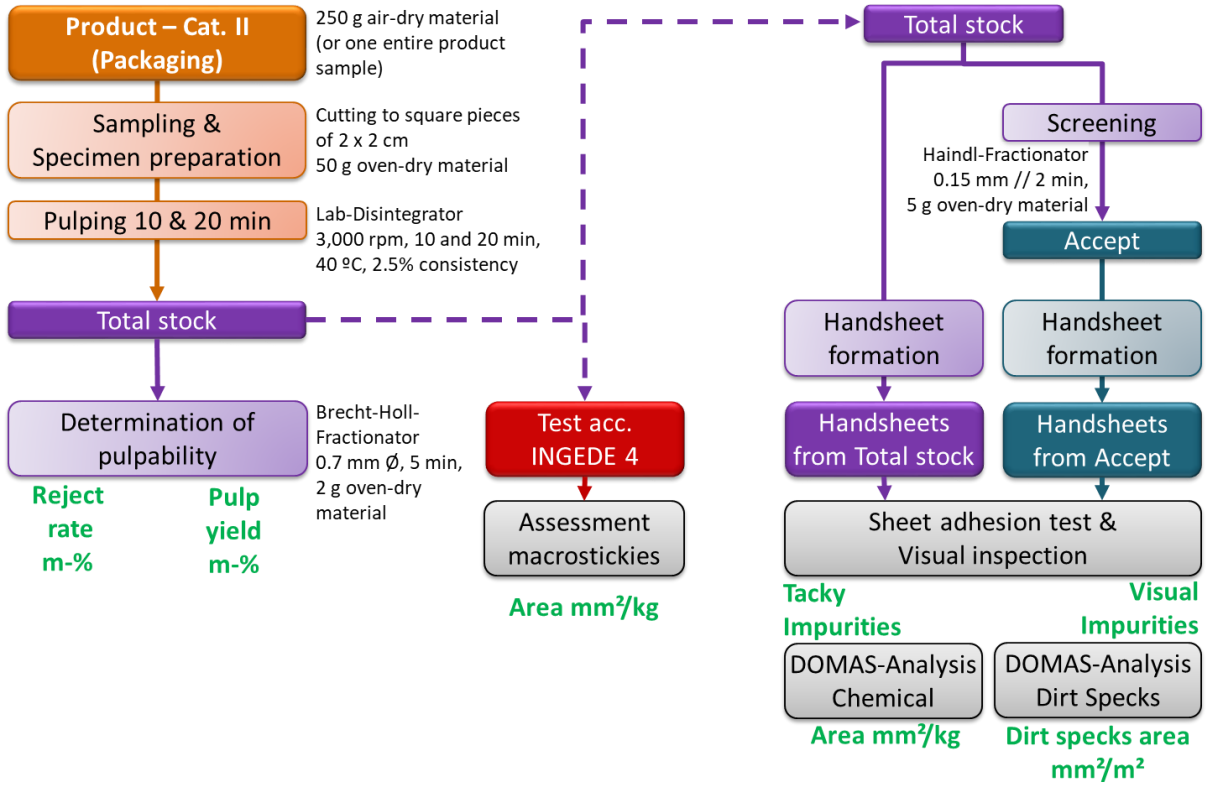

Figure 1: Flowchart of test methods

The test results were evaluated on the basis of the criteria given in PTS-RH 021 (version 2019):

- Defibration behaviour of the fibre material of the paper product: Reject rate after 20 minutes of disintegration, and description of the rejects
- Fragmentation and screening behaviour of additives (print & varnish, adhesives, coatings)
- Potential for stickies: sheet adhesion test for total Pulp and accepts
- Potential for optical inhomogeneity (specks): visual examination of hand sheet from total Pulp and accepts
- Other: change in water colour and foaming behaviour

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The results of the additional tests were evaluated according to further criteria:

- Defibration behaviour of the fibre material of the paper product: Reject rate after 10 minutes of disintegration, and description of the rejects
- Potential for stickies:
  - Comparison of macrosticky values with literature values[9] of relevant recovered paper grades
  - Evaluation of macrosticky values according to the Italian evaluation system Aticelca 401/2019[10]
  - Identification and quantification of sticky substances by DOMAS NIR Imaging
- Potential for optical inhomogeneities (specks): comparison of speck area with literature values[9] of relevant recovered paper grades

[9] Schabel, Krebs: Neue Methoden zur Erfassung der Altpapierqualität hinsichtlich der Kriterien der Neufassung der DIN EN 643 zur Charakterisierung der Altpapiersorten. IGF19118 N, Sachbericht, Darmstadt 2019

[10] http://www.expra.eu/uploads/downloads/events/ATICELCA%202018.02.22.pdf