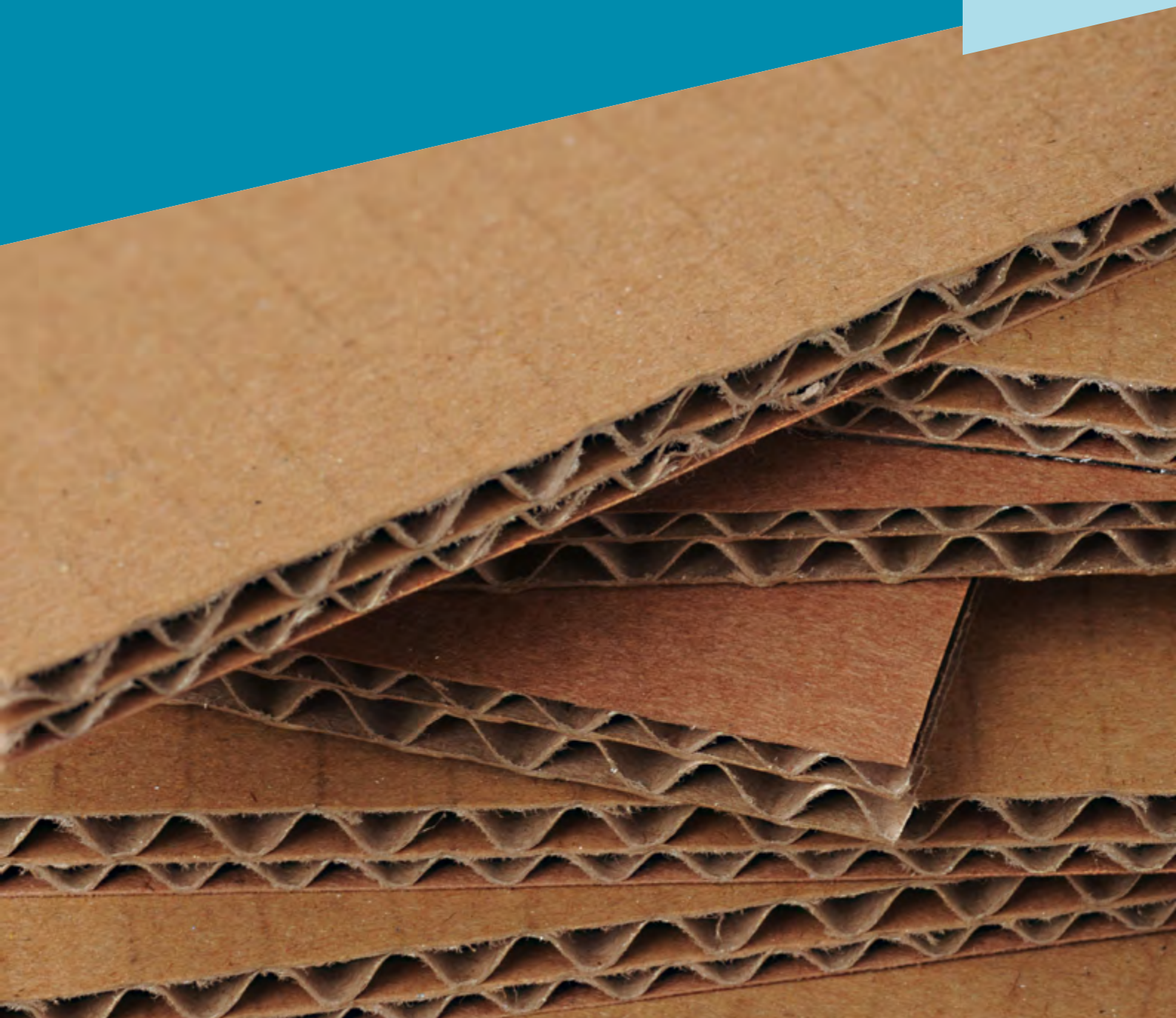
FEFCO
Corrugated Packaging

FACTSHEET ON RECYCLABILITY
CORRUGATED CARDBOARD PACKAGING



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SUMMARY

The upcoming Packaging and Packaging Waste Regulation (PPWR) is set to significantly reshape the European packaging landscape by establishing harmonized rules across the EU to reduce waste, improve resource efficiency, and foster a circular economy. A key focus of the regulation is ensuring that all packaging placed on the market is recyclable supported by clearer design for recycling requirements and standardized testing methods.

PPWR will introduce strict recyclability criteria, requiring packaging to be designed so that materials can be effectively collected, sorted and recycled. This includes mandatory design for recycling guidelines and recyclability performance grades that will influence market access. Testing procedures will also become harmonised at EU level, ensuring consistency and reliability across Member States. Companies will need to demonstrate recyclability compliance, which will not only increase transparency but also drive innovation in packaging design and material choice.

This document provides an overview of the different recycling methods of corrugated board packaging. Based on technical and operational studies, the aim is to demonstrate that corrugated cardboard packaging can be recycled by **existing recycling schemes** and by **design**.

This document should be linked to the FEFCO design for recycling guidelines. Before ensuring the final recyclability rate of packaging, it is necessary to check its level of design for recycling. In addition, certain characteristics listed in the design guidelines may necessitate further testing.

This document is currently **version 1.1** (October 2025), and is based on external studies requested by FEFCO[1]:

- Sorting performance of corrugated packaging in Europe – RecycleMe (2025)
- Test report RAP-20251143 for FEFCO – Celabor (2025)
- Test of recyclability No 25.0225 for FEFCO – CTP (2025)
- CEPI-report_PMV-25-099 for FEFCO - TU Darmstadt (2025)

[1] All technical reports can be made available on request by FEFCO secretariat. This report is a summary of the technical findings.

GLOSSARY

Reference

EN 643 standard: Paper and board - European list of standard grades of recovered paper and board

This document defines the types of recycling paper and board used as raw materials for recycling in the manufacture of paper and board products in the paper industry. It also specifies tolerances for unwanted materials, as well as the composition of papers and boards for recycling. Unusable materials (prohibited and unwanted materials) are clearly defined for all those involved in the management of paper and board for recycling.

Types of collection

Household collection of paper and board: this is paper and cardboard collected from households. It can be done via two different streams, where graphical paper (newsprints and magazines) is collected separately from the paper based or board packaging fraction. In many cases these two are collected together. Non-paper materials are not permitted at levels designed under EN 643 for the given grades.

Household commingled collection: this is paper and cardboard collected with other types of packaging such as plastics, metals or beverage cartons. Sorting is needed to separate the different materials into their corresponding streams for recycling. This is typically done in a MRF (Materials Recovery Facility).

Industrial separate collection of paper and cardboard: this is paper and cardboard materials produced as part of an industrial process which is kept separated from other waste streams and collected separately as well. Often the composition of these streams is constant, very likely predominantly packaging and with little contamination of non-paper materials.

Mixed Industrial Waste collection: if the various waste streams generated on an industrial site are too small in tonnage, they are collected with other materials. This is often agreed with the contracted waste management company so that subsequent sorting results in good quality homogenous waste streams destined for the reprocessing installations.

Sorting

Materials Recovery Facility: specialised facility where collected waste materials are sorted and prepared for shipment to reprocessing facilities.

General

EU	European Union
EN	European Standard
NIR	Near Infra-read
UBC	Used Beverage Carton
OCC	Old Corrugated Cardboard
OIW	Ordinary Industrial Waste
PE	Polyethylene
PPWR	Packaging and Packaging Waste Regulation

ABOUT FEFCO AND CORRUGATED CARDBOARD PACKAGING

FEFCO, the **European Federation of Corrugated Board Manufacturers**, represents the interests of the industry across Europe and addresses a wide range of issues, from **technical, environmental, regulatory** topics to **economic** questions.

Corrugated cardboard packaging plays a strategic role in ensuring the resilience and efficiency of the European Union's supply chain. Serving as the backbone of logistics for essential sectors such as food, pharmaceuticals, and consumer goods, it enables the circular, safe, and efficient transport of approximately 75%[2] of goods across Europe.

Corrugated cardboard also provides excellent product protection thanks to its distinctive wave-shaped structure, shielding goods from pressure and impact during transport and storage. Despite its strength, it is lightweight, reducing material use and transportation emissions. Ongoing innovations in packaging design continue to lower material consumption without compromising protection — supporting the broader goals of sustainable resource use.

As part of the paper and cardboard packaging family, corrugated cardboard makes its way into the hands of consumers, who then discard it. This **primary, secondary** or **even tertiary packaging,** used either in B2C or B2B application, is recycled via the paper and cardboard packaging stream.

Paper and board are the most recycled packaging material in Europe. Paper and board packaging recycling in the EU is a long success story, with over 80%[3] recycling rate. Recycled paper, typical grades 1.02 and 1.04, is used to make new corrugated products

Corrugated Cardboard as a material

Corrugated board consists of one or more plied of fluted paper glued to a flat ply of paper or board or between several flat plied [ISO 4046].

The combination of flat sheets of paper (called "liners") is glued to a crenulated corrugated inner medium (called "fluting"). These layers of paper are assembled to one another (typically using a starch glue) in a way which gives the overall structure a better strength.

Both liner and fluting can be manufactured from primary wood fibers from sustainably managed forests and/or from recovered fibers from paper for recycling.

[2] FEFCO - https://www.fefco.org/circular-by-nature

[3] Eurostat data 2022

DEFINING RECYCLABILITY

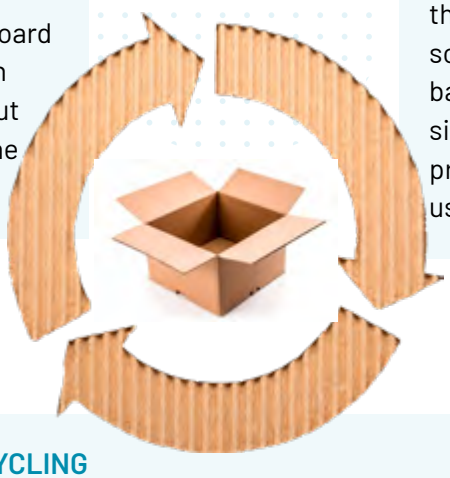
Recyclability refers to the potential for packaging materials to be reused through the recycling process. It involves three key steps: **collection, sorting**, and technical **recycling**. Packaging is considered recyclable only if it can be effectively collected, properly sorted, and directed into an existing recycling stream, such as those for corrugated cardboard. Additionally, the material must be compatible with the recycling process without causing significant disruptions.

In Europe, recycling systems for paper and cardboard differ from country to country, both in the household and industrial environment.

Corrugated board is a sustainable material, based on a renewable resource and used to make recyclable products. In practice, the recyclability of packaging products will be determined by composition and design, and by the way they are collected, sorted and presented for reprocessing**.**

COLLECTION

Since recycling always starts with collection, it is important to understand how paper and cardboard packaging is collected. Collection systems vary across countries, but also depending on the origin of the waste (household vs industrial).



SORTING

Depending on its collection, the packaging may be sorted in sorting facilities. It will be sorted based on some criteria such as size and Shape via mechanical process, as well as material using optical sorting methods.

RECYCLING

Cardboard material grades form the basis of the recycling process. Corrugated packaging is recycled in paper mills with conventional process for packaging that operates on a continuous flow basis and can handle a range of paper for recycling grades as its raw material.

COLLECTION OF CORRUGATED PACKAGING

Since recycling always starts with collection, it is important to understand how paper and cardboard packaging is collected. In Europe (EU27 + NO, CH, UK), **47 million tons of fibre-based packaging are consumed each year**, of which 42 million tons are ultimately collected.[4]
The material collected comes from two different sources:

- **Households** (21%)[5]
  Household packaging becomes waste if the household discards it or intends to discard it at home. A household refers to **any person who privately consumes or uses** a packaged product.

- **Industrial & Commercial** (79%) [6]
  In contrast to household packaging, industrial and commercial packaging refers to waste generated in professional or industrial contexts during business activities. In this case, industrial refers to large industrial sites for 31%, and commercial refers to smaller producers for 48%.

These two sources have significantly different recycling systems both in terms of collection and sorting. The quality of the collected material often results in a waste stream where sorting is not necessary.

Therefore, depending on where packaging is discarded and how this waste is collected will help determine whether the package will undergo a sorting step, before arriving at a recycling mill.

European countries household paper and cardboard waste collection

Across European member states, different collection systems are in place for household wastepaper and cardboard collection, the two main ones being:

- **Selective collection of paper and cardboard:** dedicated to paper and cardboard waste. Most of EU countries define their own paper-content threshold – or minimum percentage of paper - a packaging must meet to be accepted in the system. It can range from 50% to 95%.
- **Commingled collection of recyclable materials:** mixed collection of recyclable packaging – *plastics, metals, beverage cartons, paper and cardboard and sometimes glass.*

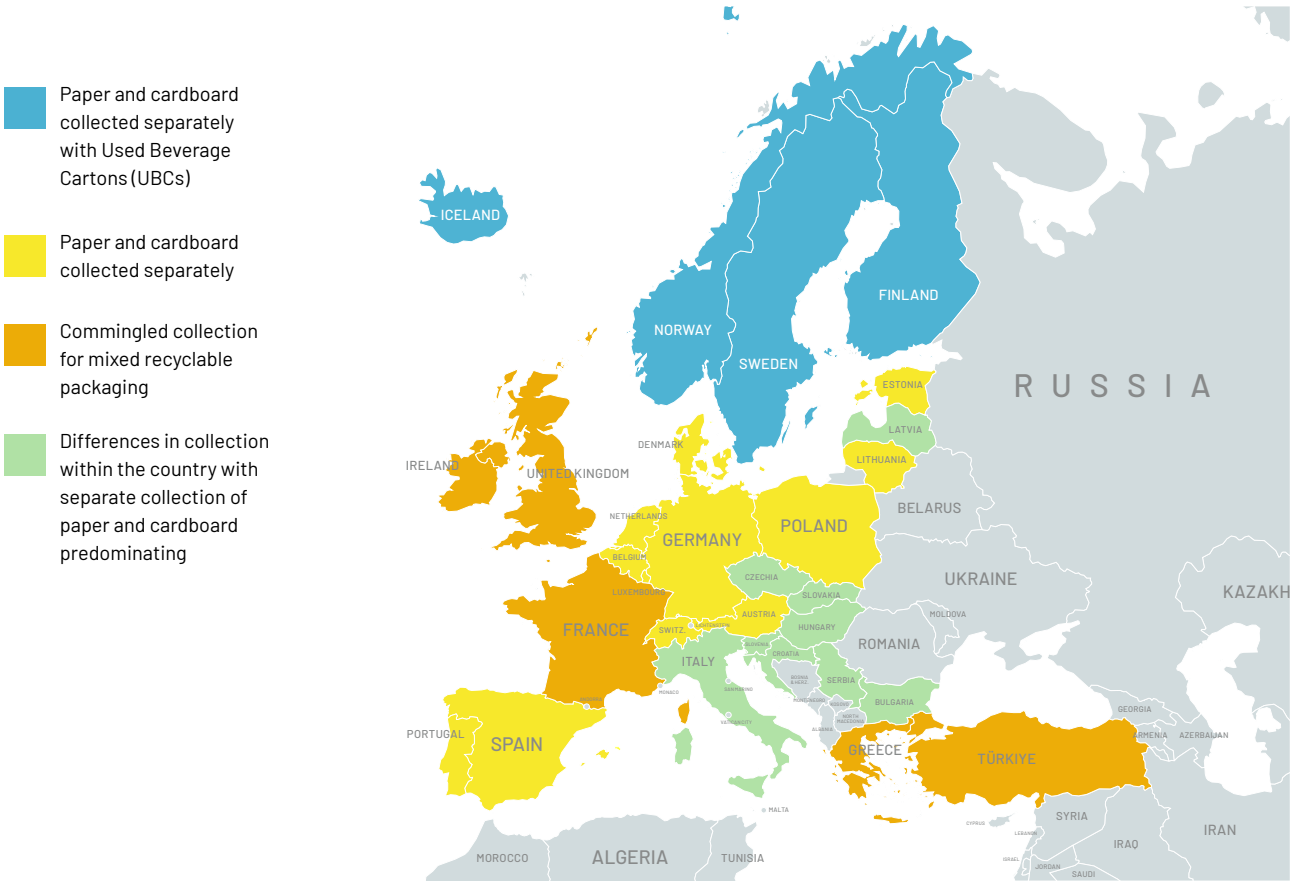


Figure 1: Overview of paper and board collection systems in Europe – source: FEFCO

[4,5,6] All data come from Guidance on the improved collection and sorting of fibre based packaging for recycling – 4EverGreen – October 2024 via RISI; Expert interviews; Press search; FAO; OECD; Cepi, team analysis, 2020

European countries industrial paper and cardboard waste collection

Currently, monitoring industrial waste collection is particularly complex, as individual industries and economic operators can be responsible for establishing their own collection systems, within legislative frameworks that differ from one country to another. Overall, the two most common streams for paper and cardboard industrial waste collection are:

- Mixed collection as Ordinary Industrial Waste (OIW) in reference to general waste produced by industries such as cardboard plastics, paper and opposing to hazardous waste. It is similar in nature to regular municipal solid waste.
- Selective collection of paper and cardboard.

Large companies generally rely on private waste management companies to collect paper and cardboard and recycle. However, some small companies use the municipal waste management service (*i.e. their waste joins the collection of household packaging*).

	LARGE BUSINESSES	SMALL BUSINESSES
EXAMPLES OF INDUSTRIES	Manufacturers, supermarkets, hospitals...	Craftsmen, stores* and retailers * *Rather independent shops that are not managed by a large group's central purchasing unit.*
GENERATION OF OIW	Large volume	Small volume
COLLECTION STREAM	Separate collection is often in place	Unusual separate collection
COLLECTION MANAGER	Private waste management service	Public waste management services are often used
REMARKS	• Better knowledge and monitoring of regulations • Sufficient sorting space and volumes to enable massification and generate logistical savings, including reverse logistics to internal massification platforms.	• Less familiar with regulations • Lack of space to multiply collection containers, insufficient volumes to "amortise" the costs associated with multiple containerisations.

Figure 2: Description of the company's industrial profiles for waste collection[7]

The main findings relating to industrial waste collection are the following:

- Levels of source sorting and separate collection of sorted streams vary according to end-user profile and collection stream.
- Collection practices vary widely: separate collection by material, joint collection or mixed collection.
- However, paper and cardboard remain the fraction most frequently sorted at source by industrial operators for direct shipment to paper mills. In France, for instance 94% of industrial paper and board is collected separately[8]

[7] Source: Prefiguration study of the industrial and commercial packaging EPR – ADEME - February 2024
[8] Source: Prefiguration study of the industrial and commercial packaging EPR – ADEME - February 2024

SORTING OF CORRUGATED PACKAGING

Sorting of materials is directly linked to the collection system. Depending on how the material is collected, it may need additional sorting, or not.

In Europe, paper and cardboard are sorted according to **standard EN 643** which defines different grades of paper and cardboard quality.

The definitions and the general requirements in EN 643 are the source of the material, the prohibited materials, the unwanted materials, the moisture level and the form of delivery. The standard lists around 100 different grades.

EN643: European list of standard grades of paper and board for recycling

Examples of sorting output fractions according to EN 643:

- **1.02**: Mixed paper and board
- **1.04**: Corrugated paper and board packaging
- **1.05**: Ordinary corrugated board
- **1.11**: Sorted graphic paper for deinking
- **4.01:** Unused board and shavings of corrugated material
- **5.02**: Mixed packaging
- **5.03**: Used liquid packaging board

Sorting will then add value for both the sorter (*bales value going up*) and the recycler (*quality of materials for recycling resulting in less rejects*).

Typical sorting equipment for paper and cardboard

Multiple technologies are being used in state-of-the-art sorting installations to sort out paper and cardboard. It is always a combination of **mechanical** sorting steps (based on physical properties of the material) and **optical** sorting *(based on near infra-red spectrum).*

However, all facilities are not equipped or designed to sort out all the different paper grades. This gives place to variety in the layouts of the sorting facilities.

Ballistic separator: Moving slanted metal arms that ensure the separation of paper and cardboard. Paper falls through the openings in the paddles. At the same time, because of its rigidity, cardboard will travel upward, to the overflow at the upper end of the machine.

Screens: Screens are a series of rotating discs, designed to sort different materials. Paper and other objects fall through the discs, while pieces of cardboard 'float' on top.

Both ballistic separation and separator screens also allow to perform size sorting, from large material (>300mm) to smaller ones (>50mm). Small packaging and pieces of paper (<50mm) are considered undersized residue and are often not recycled. This is due mainly to contamination with other small materials such as plastics, dust, rocks...

Some new modern facilities try to sort this fine fraction out to recover the maximum of valuable materials.

NIR (Near InfraRed): An optical sorter is shooting a specific light spectrum on the surface of the material. For this the Near-InfraRed range (or NIR) is used. The device is analysing the reflecting NIR-spectrum. Based on this, it can determine the type of material. For paper and cardboard materials, NIR is used to sort out paper for deinking fractions. It can also be used to identify non-fibre materials and to take out unwanted materials from the stream.

VIS (Visible Light): A high-resolution camera technology to allow separation by color and/or shape. This technology is often combined with NIR technology to identify specific colored material.

Manual control: Quality control is often performed by operators at the end of the sorting process. This allows any remaining contaminants to be removed manually.

Sorting after household separate collection of paper and cardboard

This collected fraction is dedicated to **paper mills with conventional process**. After separate collection of paper and cardboard, additional sorting than the one performed by the consumer at source, is not always taken place. Additional sorting takes place with the objective of separating the paper for deinking (grade 1.11) from other paper and cardboard packaging. In that case, the graphical paper is sent to deinking mills, whereas the other materials are sent to standard paper mill for recycling.

Sorting is then done between 1.11 (paper for deinking), 1.02 or 1.04 (OCC), 5.02 (mixed paper), as well as remaining residue waste. This reflects the EN 643 grades (see above).

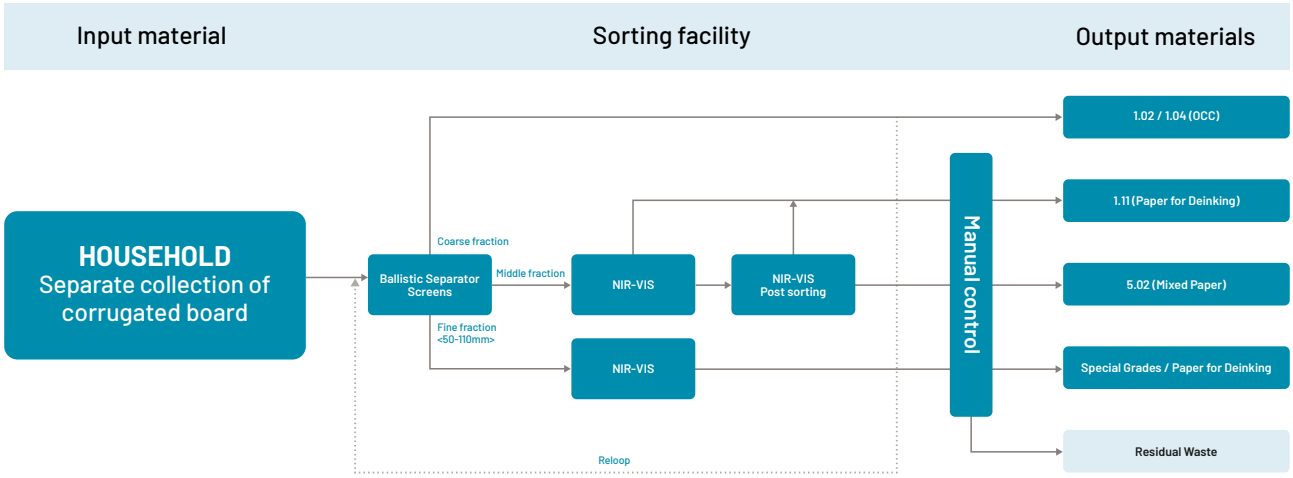


Figure 3: Simplified process of a paper and cardboard sorting facility – Source: FEFCO

Sorting after commingled collection

Sorting is taking place in case of commingled collection of materials. In that case, paper and cardboard must be separated from plastic packaging, metal packaging and used beverage cartons in state-of-the art sorting facilities. There, paper and cardboard will be sorted according to EN 643 grades and sent out to **paper mills with a conventional recycling proces** or recycling mill with **specialised Fibre-Based Composite Packaging (FBCP) process.**

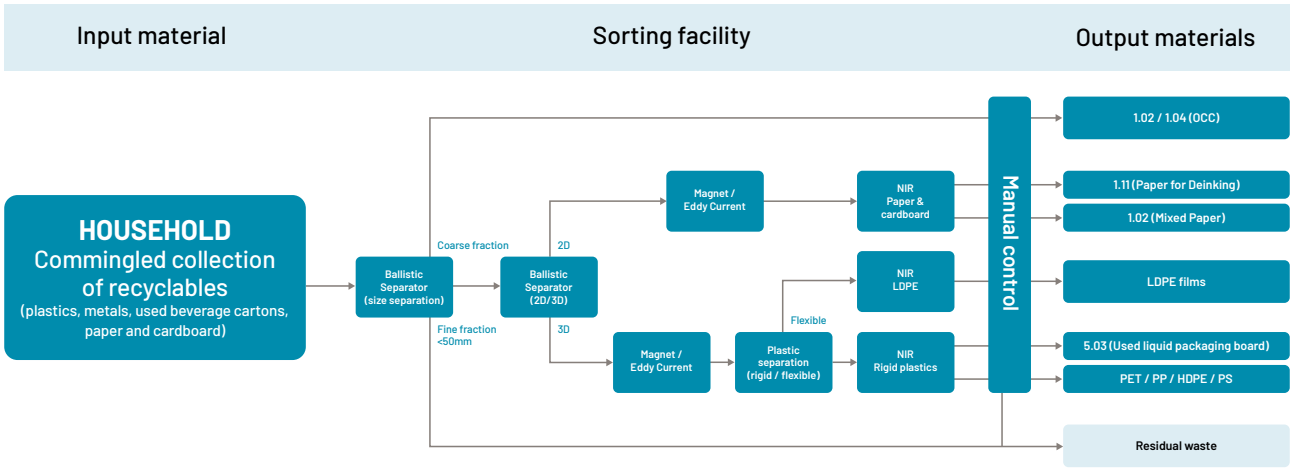


Figure 4: Simplified process of a commingled sorting facility - Source: FEFCO

Sorting after industrial collection of paper and cardboard

In the case of a separate collection of industrial paper and cardboard, the stream can be balled as such and brough to paper manufacturer, without further sorting, if the quality of the stream is homogeneous enough. This remains much dependent on the specific activity of the economic operator.

In the case of mixed collection, the materials may be sorted into an industrial sorting centre or waste collection centres, where the cardboard will be separated and sent to paper mills.

Current practices: overview of waste management companies' processes

In a recent project, FEFCO, through the consulting firm *RecycleMe*, has contacted 50 companies involved in paper and cardboard waste management. From these, six were selected for interviews to represent different waste streams, office, industrial, and household waste, as well as varying recycling systems. The aim was to analyze the **origin, sorting processes**, and **quality of the output materials** generated from collected paper and board materials. Table 5 provides an overview of the practices adopted by several waste management companies handling paper and cardboard. While not exhaustive, it offers a representative picture of the different systems in place.

	Woodside (Berk, UK)	Paprec Trivalo (Guichainville, FR)	Paprec La Corbeille Bleue (Toulouse FR)	Peeters Recycling (Swalmen, NL)	Knol recycling (Hengelo, NL)	AVG (Cologne, DE)
ORIGIN: INDUSTRIAL WASTE	● Small shops, production sites, offiCes	●	● Small shops, production sites, offices	●	●	●
ORIGIN: HOUSEHOLD WASTE	●	●	●	●	●	●
PRE-SORTING BY CONSUMER	●	●	●	●	●	●
ADDITIONAL MANUAL SORTING PROCESS	● To remove plastics from paper batches	● For quality control	● Via running conveyor: 2.05, 06 / 1.11 / 1.04 / 1/0	●	●	●
ADDITIONAL MECHANICAL SORTING PROCESS	●	● OCC ballistic machine, NIR: 1.11 / 1.05 /5.02		● OCC ballistic machine: 1.05 / 1.04 / 1.09 / 1/02	● If needed ballistic machine to sort large cardboard pieces	● Ballistic machine: 1.11, 1.04, 1.02 and fines
ANNUAL VOLUME TREATED (TONS)	**16 kt**	**10 kt**	**22 kt**	**54 kt**	**10 kt**	**150 kt**
RATIO CORRUGATED CARDBOARD TREATED		**30 %**	**20 %**			**40 %**
WHERE ARE THE BALES SOLD?						

Figure 5: Examples of practices of waste management companies for paper and cardboard

Current practices analysis led to the following insights:

- **Sorting at source increases quality of sorted paper:** highest quality of sorted paper and board is consistently achieved when waste is sorted directly at the point of generation whether in offices, companies or households. This early separation minimises contaminations and improves output quality.
- **Mechanical sorting yields high quality:** when automated sorting lines are used, sorting of paper and board, including corrugated, is efficient and delivers high-quality outputs that meet EN 643 standards.
- **Manual sorting is still common in the professional waste management environment:** manual sorting by operators on conveyors can achieve comparable quality, particularly when dealing with pre-sorted industrial waste. The extra cost of this operation makes it viable only for high-value material or low-volume.

Sorting efficiency of corrugated packaging: operational sorting tests

Furthermore, FEFCO, still trough the consulting firm RecycleMe, has conducted operational sorting tests with corrugated packaging in two different sorting facilities[9] to improve our understanding of the sorting efficiency of corrugated packaging in the few cases where mechanical sorting must be carried out. The tests were carried out in a:

- Sorting facility for **household selective commingled collection** (France)
- Sorting facility for **selective collection of paper and cardboard** (Germany)

Five samples, representative of standard corrugated cardboard packaging, were selected for these tests. These five references will provide an overview of the sorting performance of corrugated cardboard and are described in Figure 6.

	REFERENCE 1	REFERENCE 2	REFERENCE 3	REFERENCE 4	REFERENCE 5
TYPE	Laminated corrugated box, with PE <5%	E-commerce packaging	American box (FEFCO 0201)	Fruit & Vegetable tray	Double fluted corrugated tray
SIZE (CM)	15 x 15 x 9	36.5 x 24 x 21	37 x 26 x 12	57 x 40 x 8	50 x 30 x 10
PHOTO					

Figure 6: Tested corrugated packaging

[9] Sorting performance of corrugated packaging in Europe – RecycleMe (2025)

OPERATIONAL SORTING TESTS IN FRANCE: COMMINGLED HOUSEHOLD COLLECTION

System

In France, all household packaging is collected via the "yellow bin": plastics (flexible and rigid), metals (ferrous and non-ferrous), used beverage cardboards and paper and cardboard packaging are collected together.

Plant description

TRIVALO 27 sorting center is located in Guichainville (FR). It is operated by Paprec on behalf of a consortium of local authorities, under a design-build-operate-maintain contract. The facility has an annual processing capacity of 35,000 tons / year. The sorted fractions are grades 1.05, 5.02, 1.11, PE-films, PE/PP, mixed flexible plastics, PET, ferrous metal, non-ferrous metals, and used beverage cartons.

Testing protocol

- **Samples preparation:** samples are mixed with the waste stream, including compaction of waste as done in collection trucks
- **Operational test:** quantitative tracking of packaging orientation through the entire sorting process. Test is based on 100 samples, introduced at the beginning of the process. Samples are then counted at the end of the process to determine in which fraction they are found.

Results

The results are communicated in % of samples reaching the stream, according to EN 643 grades.

Packaging is considered fully sortable into one dedicated stream in case the sorting efficiency is higher than 80%[10].

	1.05	1.11	5.02
Reference 1	11	23	56
Reference 2	94	0	6
Reference 3	83	0	17
Reference 4	86	0	14
Reference 5	98	0	2

Conclusion

With a sorting efficiency varying from 83 to 98, references 2 to 5 can be considered fully sortable into the 1.05 stream, which is the targeted stream for corrugated packaging.

Reference 1 is mostly sent to 5.02, for mixed packaging, fraction due to the presence of PE lamination on its outside. Even if it is not the targeted fraction, the packaging will still be sent to a paper mill with a conventional recycling process for recycling and is not contaminated another stream.

[10] As there is currently no sorting evaluation protocol for paper and cardboard, we rely on the RecyClass sorting evaluation protocol for plastic packaging to interpretate the sorting result [https://recyclass.eu/wp-content/uploads/2024/01/SORTING-EVALUATION-PROTOCOL-FOR-PLASTIC-PACKAGING_-V2.0-FINAL.pdf].

OPERATIONAL SORTING TESTS IN GERMANY: SELECTIVE COLLECTION OF PAPER AND BOARD

System

In Germany, pre-sorting of paper and cardboard is done at source by the consumer and collected via the "blue bag". This stream is sometimes sent to a sorting facility for paper and cardboard to separate further the different grades of material with the main objective to extract paper for deinking.

Plant description

AVG is located in Cologne (GE) and receives the totality of Cologne's collected paper and board waste. The sorting process combines mechanical screens (ballistic separator) with optical sensors (NIR & VGA). AI comes in support in optical sorting making this facility a state-of-the-art sorting installation for paper and cardboard. The sorted fractions are grades 1.04, 1.02 and 1.11.

Testing protocol

- **Sample preparation:** compaction of waste as done in collection trucks
- **Operational test:** quantitative tracking of packaging orientation through the entire sorting process. Test is based on 50 samples (30 for reference 5 due limited availability), introduced at the beginning of the process, after the plant being emptied of other waste. Samples are then counted at the end of the process to determine in which fraction they are found.

Results

The results are communicated in % of samples reaching the stream, according to EN 643 grades.

Packaging is considered fully sortable into one dedicated stream in case the sorting efficiency is higher than 80%.

	1.04	1.02	1.11
Reference 1	0	84	16
Reference 2	70	25	5
Reference 3	100	0	0
Reference 4	100	0	0
Reference 5	97	3	0

Conclusion

With a sorting efficiency varying from 97 to 100, references 3 to 5 can be considered sortable into the 1.04 stream, which is the targeted stream for corrugated packaging. Reference 2, with sorting efficiency of 70%, is also considered highly sortable in the 1.04 fraction.

Reference 1 is mostly sent to 1.02, for mixed paper and board, fraction due to the presence of PE lamination on its outside. This is also one of the targeted fraction for corrugated board, the packaging will still be sent to a paper mill with conventional process and is not contaminated another stream.

General conclusions of the sorting performance report of corrugated cardboard packaging can conclude that corrugated cardboard are **efficiently collected and sorted** in Europe, despite the different systems. Qualitative sorting is carried out for both household and industrial paper and cardboard waste.

The EN 643 standards guarantee high quality materials including corrugated cardboard intended for recycling mill with conventional process.

It is important to note that characteristics of packaging design such as heavy inks coverage or lamination / coating on the outside can orient corrugated packaging in another material stream, such a 5.02 or 1.02, but that will also reach the recycling process and conventional recycling mills.

How to ensure corrugated cardboard is easy to sort?

In case it goes through a sorting facility, the packaging is sorted based on:

- Its size and shape, using mechanical methods. Large pieces of cardboard may be oriented directly to the OCC stream and not go through the entire process.
- Material using optical sorting methods

Reducing the number of other materials, such as lamination or inks, will increase the likelihood of corrugated packaging being sorted as such.

RECYCLING OF CORRUGATED PACKAGING

Recycling process of corrugated packaging

Recycling facilities for fibre-based packaging can differ from each other on the degree to which they can handle different types of materials. Corrugated cardboard packaging are fitting the **paper mills with a conventional recycling process.** Standard equipment and process is the following:

- **Layer breakdown of bales**
- **Pulper:** the material is blended with water. This enables the paper to disintegrate. Fibres can be separated from unwanted components. In standard mills, the temperature is typically around 40° C and the pH value is about pH7. These mills typically have a low consistency pulper (5 % fibre concentration). As an alternative, drums can be used.
- **Screens:** unwanted coarse particles removed through filtration (sorting by size)
- **Cleaner:** finer particles removed via hydro cyclones (sorting by density)
- **Paper machine:** sheet formation and drying process
- **Winding:** reels of paper

What happens to rejects?

Currently, all materials rejected at the conventional recycling process are incinerated (sometimes they serve to heat and to supply steam to different process steps in the paper mill) or landfilled. Rejects cannot be re-sorted and oriented towards another recycling stream. Rejects are considered disturbing and cost generated elements in a recycling process.

Laboratory test methods

In the frame of PPWR, all packaging put on the EU market must be recyclable by design from 2030. To study recyclability of a packaging, the control selection of raw materials used in production operations must ensure that the recycling processes are not negatively affected. In other words, packaging components must be compatible with known, relevant and industrially available recycling technologies.

So far, there are a number of test and evaluation protocols, standards and laboratories engaged on assessing recyclability of paper & board packaging, including corrugated. In many cases the acceptability of a product for recycling depends upon a wider range of factors such as the way it is collected and sorted, its application and the likelihood of contamination.

Harmonisation and standardised test method are expected with the implementation of PPWR secondary legislation.

In the meantime, to demonstrate the recyclability of corrugated packaging, FEFCO has carried out several recyclability tests with different methods and labs. All tests are based on the same principles as shown in the table below.

	CEPI RECYCLABILITY TEST METHOD VERSION 3	CTP-REC21
SAMPLE PREPARATION	Components removed Cut 3x3 cm	Entire product, hand torn (if not cut) 3x3 cm
PULPING	2.5 % - 40° C – 10 min. (can be extended to 20) Filtrate: evaporation residue, COD and BOD (optional)	3 % - 40° C – 15 min. (can be extended to 30 or 45) Filtrate: COD and evaporation residue Handsheets: visual aspect and adhesion test (starting point)
COARSE SCREENING	Ø 5 mm 5 min -> rejects	Ø 5 mm 20 min -> rejects
ACCEPTED PULP (COARSE)	Handsheets: visual aspect and adhesion test (mid-point)	Directly to fine screening step (Somerville in cascade)
INTERMEDIATE SAMPLE	Yes (20 g)	
FINE SCREENING	//15/100 mm 20 min -> rejects (correction factor)	//15/100 mm 20 min -> rejects
ACCEPTED PULP (FINE)	First 50 L collected Handsheets: visual aspect and adhesion test (end point)	Totally collected Handsheets: visual aspect and adhesion test (end point)
HW CLEANING	-	Accepted pulp -> Handsheets: visual aspect and adhesion test

Figure 8: Methodologies used for FEFCO samples recyclability testing

These methods enable analysing both process parameters (coarse reject, fine reject, dissolved and colloidal substances and sticky particles with substances and sticky particles with a diameter smaller than 2 mm) and quality parameters (sheet formation and interfering materials like adhesiveness and visual impurities)

The same samples used for sorting were also tested for recyclability.

Effective recyclability of corrugated packaging

The recyclability of paper and cardboard packaging, including corrugated cardboard packaging, can be determined by means of those laboratories procedures that simulates the most relevant industrial phases in a conventional recycling mill. In particular, it defines the parameters of interest:

- Ease at which the fibres can be separated using equipment of a recycling mill with a conventional process
- The potential to form sheets out of the recovered fibres without significant disruption
- The visual appearance when formed into sheets
- The level of coarse and fine rejects
- The level of fragmentation of disrupting materials (adhesives, metals, plastics film)
- The level of or colloidal substances below 12 microns resulting from non-paper components in the tested sample

To ensure a comprehensive result between the different parties, the data set has then be inserted into an Excel scorecard template for processing developed by 4EverGreen[11]. The tool will return scores for each individual parameter and an overall recyclability score and assessment of the technical recyclability for a dedicated recycling mill process, ranging between -100 and +100. A positive score states that the packaging is technically recyclable in this type of process, the higher the score, the better the technical recyclability with a dedicated process.

[11] https://4evergreenforum.eu/about/industry-tools-and-guidelines/

Sample	Picture	Technical recyclability score (ranging from -100 to +100) according to the laboratory and procedure		
		Lab 1 (test method: CEPI v3)	Lab 2 (test method: CEPI v3)	Lab 3 (test method: CTP-Rec21)
REFERENCE 1 LAMINATED CORRUGATED BOX, WITH PE LAYER (<5%)		92	91	92
REFERENCE 2: E-COMMERCE PACKAGING		92	91	93
REFERENCE 3: AMERICAN BOX (FEFCO 0201)		97	96	97
REFERENCE 4: FOOD & VEGETABLE TRAY		89	93	94
REFERENCE 5: DOUBLE FLUTED CORRUGATED TRAY		98	93	98

Figure 9: Technical Recyclability Scores of corrugated packaging

The test results, shown in figure 9, show that all tested samples are suitable for standard mill recycling and are considered "best in class" in view of the score. The results between laboratories are consistent and accurately reflect the good repulpability and quality of the fibres when recycling these packaging materials.

For all tested samples, the packaging creates a high screening yield in a recycling mill with conventional process and is therefore considered 'best in class'.

METHODS AND GUIDELINES RELEVANT TO THE RECYCLABILITY OF CORRUGATED PACKAGING

This factsheet is based on expert industry knowledge and indenpendant technical studies commissioned by FEFCO to demonstrate corrugated carbdoard packaging high recycling efficiency.

Testing, conducted in line with industry standards, has shown that corrugated packaging is sortable with high efficiency and fully recyclable in the process conditions operated by conventional recycling mills. **This confirms that corrugated is a truly circular material.**

As demonstrated, the recyclability of packaging products will be determined by composition and design, and the way they are collected, sorted and presented for reprocessing. As collection, sorting and reprocessing of corrugated packaging is already established, it is important that packaging designed ensure that the material remains recyclable by design.

Design for Recycling offers insights into the compatibility of different elements / parameters of a packaging with given recycling stream.

Guidelines are living documents, as they can be continuously updated on laboratory test results. For features of packaging that are not covered by the guidelines, testing of the packaging is recommended via recognised procedure(s).

		CORRUGATED PACKAGING		
		FULL COMPATIBILITY FOR REPROCESSING IN STANDARD MILL	**CONDITIONNAL COMPATIBILITY FOR REPROCESSING IN STANDARD MILL**	**LOW (OR NO) COMPATIBILITY FOR REPROCESSING IN STANDARD MILL**
Main body of the corrugated packaging	**Material composition**	**Fibrous material** can be defined as fibre itself, filling material, starch, coating colour including binder, sizing, wet and dry strength agents including bound water compatible with recycling process.		
		Natural fibre-based paper and board suitable for recycling made of wood-based fibres or other fibre sources leading to similar pulp quality as wood-based fibres.	Other fibre sources leading to different pulp quality as wood-based fibres: bagasse; palm fibre; rice straw; wheat straw; barley straw; oat straw and other plant fibres.	• **Other fibre sources:** glass fibres, carbon fibres • **Synthethic fibres:** plastics, cellulose (Viscore, Cellophane, Lyocell, Modal…), stone paper • **Prohibited materials** for paper and board recycling: any material which presents a hazard for health, safety and environment, such as medical waste, animal products or toxins.
	Colour	Natural and pale colours, NIR sortable Mass tinted pulp	NIR sortable dark-colours Intense and bleeding colors	Non-NIR sortable colours **applied over the entire surface / entire mass.**
	Barrier, coating, lamination	• **Uncoated and unlaminated board is preferable.** Alternatively, **one-sided plastic coating / plastic laminate** with a different density from that of fibres (excl. range from 0.95 to 1.15 g/cm3) **or if it can be separated / sorted out in the stock preparation.** • Polymeric material could be of **conventional, biodegrable, or compostable** material if it disintegrated into large fragments. • Adhesive agent lamination with **water-soluble adhesive / water soluble coatings.** • **Peelable laminated.** • **Adhesive barrier film:** adhesive lamination with water-soluble adhesives (PVOH, starch, etc.). • **Wet-barrier coatings:** aqueous polymer dispersions (acrylics, EEA, SB, ABS, PVDC, etc.), solvent based coatings, wax dispersion (incl. microcrystalline waxes), water soluble coatings (PVOH, EVA biobased, etc.).	• One-side plastic coating / plastic laminate • Hot and cold foil transfer. • Adhesive lamination inside the packaging (PET, mPET, PET/PE), lamination with alu containing film (6 micron+) (Alu/PE or PET/Alu/PE) etc. • Extrusion barrier coating : thermoplastics.	• **Two-side plastic thermoplastic extrusion coating / laminate** • Polymers with low shear strenght that break down in pulper unless water-soluble or unscreenable. • Coating made of oxo-degradable material. • PVC or PvdC coating. • Wax or waxed coated paper. • Silicone • Hard-sized products.
	Additives	• **Mineral fillers** (ash) such as talc, kaolin, titanium dioxyde (TiO2), starch, calcium carbonate (CaCO3). • **Wet strength agents** without negative impact on fibre recovery and recycling such as Glyoxylated polyacrylamide (GPAM). • **Dry strenght agents:** starch, CMC, Polyacrylamide, Guar gum.). • **Filler/Inorganic pigments :** Clay, CaCO3, Talc, titanium dioxide • **Binder :** S/B latex, S/A latex, Starch-biobinder. • **Sizing,** wet end : AKD,ASA, Rosin. • **Others :** Colorants/dye for shading, colorants/pigments, polyvinyl alcohol, PAC, Retention polymers.	• Wet strenght agents : PAE.	• **Wet strength agents** with negative or unproven impact on fibre recovery and recycling. • Siliconizing agents. • Water-insoluble or non-redispersing adhesive applications where it has not been specifically proven that they can be removed.
Attachments to corrugated packaging	**Closure system**	**For box making:** Paper or plastic reinforcement tape with adhesive application that does not lead to the formation of problematic stickies.	**For box making:** Staples and plastic adhesive tape that can be removed via consummer or separated via the recycling process.	**For box making:** Paper tapes with adhesive application that leads to the formation of problematic stickies or fragments in stock preparation that cannot be screened out.
Decoration of corrugated packaging	**Adhesive for label, finishing and lamination**	**For box making and closure:** • Starch-based adhesive • PVA • Application of hot-melt adhesives exempted as per the EPRC scorecard: > Softening temperature of the adhesive (according to R&B): ≥ 68°C > Layer thickness (non-reactive adhesives): ≥ 120 µm > Layer thickness (reactive adhesives): ≥ 60 µm > Horizontal dimension of the adhesive application (in either direction): ≥ 1.6mm **For lamination:** • Starch-based adhesive • Protein glues • Acrylic • Other dispserion • UV curing acrylics • PU **For labelling:** • Pressure sensitive emulsion acrylics • Pressure sensitive hotmelts • Pressure sensitive UV-curable acrylic adhesive • Water-based adhesive		• Insoluble adhesives that are not screenable • Heavy foils • Hotmelts with a softening point < 68°Cas per as the EPRC scorecard
	Inks & Decoration	• Non toxic following the EuPIA Guidlines **Inks & varnish:** • Offset printing: oil-based (mineral), oil-based (vegetable), ultra violet cured/EB-cured • Flexographic printing: solvent-based, water-based • Gravure printing: Solvent-based, water-based • Varnish : solvent-based, water-based • Electrophotographic digital printing: liquid & dry toners • Digital printing: water-based, ultra-bviolet cured, liquid toner, solid toner, got melt **Metalisation:** • Metalic components, decoration : hot and cold transfer with surface <70%	**Packaging aids :** security label, RFID tag, pull strip, plastic and metal spout, carrying handle **Metalisation:** • Metallic components, decoration: hot and cold transfer with surface >70%	• Toxic or hazardous inks (Inks that are on the EuPIA exclusion list) **Metalisation:** • PP/PET metalized laminates covering the full surface • PET metalized films covering the full surface
Other integrated component		**Bag of a bag-in-box** packaging format	• Integrated plastic components: windows or handles.	

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