RecyClass

RECYCLASS DESIGN BOOK

A STEP-BY-STEP GUIDE TO PLASTIC PACKAGING RECYCLABILITY

VERSION 2.0

PUBLISHED: JUNE 2022
LAST UPDATE: JANUARY 2025

TABLE OF CONTENT

PLASTIC PACKAGING STATE OF PLAY

MAKING PLASTIC FULLY CIRCULAR IS ESSENTIAL FOR THE SUSTAINABLE USE OF OUR RESOURCES AND THE ONLY WAY THAT THE PLASTIC INDUSTRY CAN REMAIN COMPETITIVE. THE INDUSTRY MUST, THEREFORE, RETHINK THE WAY PLASTIC PACKAGING IS DESIGNED AND PRODUCED.

WHY IS DESIGN IMPORTANT?

Re-design, being part of the waste hierarchy, is one of the key measures in effectively addressing the issue of plastic waste.

When designing packaging, the combination of different components like labels, closures, and such, pre-determines the packaging's ability to be effectively collected, sorted, recycled, and ultimately taken up in the manufacturing of new products. Each component influences the overall recyclability of a plastic packaging. Every product placed on the market should be designed considering these factors and ensuring compatibility with state-of-art recycling technologies.

This is where RecyClass steps in by offering science-based, transparent and reliable means of assessing, as well as verifying plastic packaging recyclability. In this aspect and through the collaboration with representatives from the entire value chain, the Design Book was created.

WHY A DESIGN BOOK?

This Book explains the importance of Design for Recycling in a simplified and a step-by-step approach. It is a document that can be consulted by all the industry actors and stakeholders alike, regardless of their technical knowledge of recyclability.

MAKING PLASTICS FULLY CIRCULAR

In order to tackle the issue of packaging waste and to limit its environmental impact, the European Commission (EC), National Pacts, and other industry stakeholders have set targets and commitments, that include recycling rates, packaging design, and integration of recycled content for certain types of packaging. The timeline shown here gathers the milestones that contribute to plastic packaging circularity.

KEY MILESTONES IN THE CIRCULAR TRANSITION OF PLASTIC PACKAGING

2030
- 100% of all plastic packaging to be recyclable (Plastic Strategy & EU Circular Economy Package)
- 30% recycled content for beverage bottles (Single Use Plastics Directive)
- 70% of all packaging waste to be recycled (EU Circular Economy Package)
- Mandatory recycled content in all plastic packaging.

2025
- Target of 10 million tonnes of recyclates to be used in new products (Circular Plastics Alliance)
- 25% recycled content for PET beverage bottles (Single Use Plastics Directive)
- 100% of plastic packaging to be reusable, recyclable or compostable (Ellen MacArthur Foundation Global Commitment)

2022
- Proposal for Packaging and Packaging Waste Regulation (PPWR)

2019
- Directive on single-use plastics

2018
- EU Plastics Strategy

2010
- Essential requirements for the placement of packaging to be placed on the EU market (PPWD)

2000
- Extended Producer Responsibility (EPR) systems for packaging (PPWD)

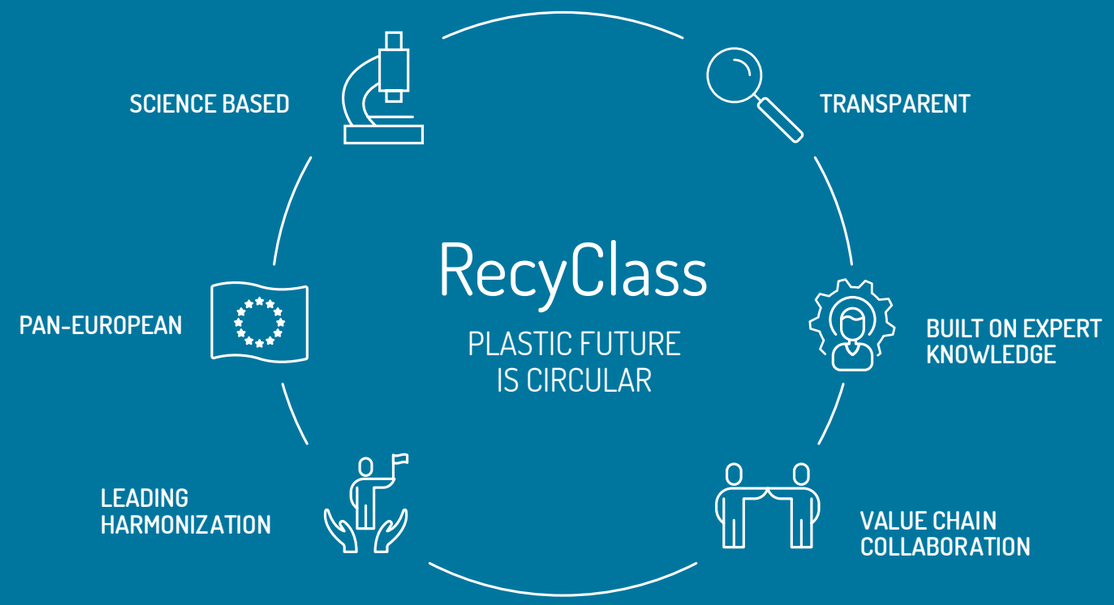
RECYCLASS – PLASTIC FUTURE IS CIRCULAR

RecyClass is a non-profit, **cross-industry** initiative that works to advance plastic packaging **recyclability** and to establish an harmonized approach towards **recycled plastic** calculation and traceability in Europe.

Activities within RecyClass include the development of Recyclability Evaluation Protocols and scientific testing methods for innovative materials which serve as the base for the Design for Recycling Guidelines and the Online Tool. RecyClass offers Recyclability Certifications for plastic packaging and Recycled Content Traceability Certification for plastic products.

RecyClass' vision is to make plastic packaging, and eventually all plastics, circular by making them recyclable and boosting the transparent uptake of recycled materials. By offering a comprehensive set of tools and giving advice, RecyClass aids the industry in its journey towards circular plastics.

Recyclability and circularity are the core components of this transition, and they must be paired with appropriate benchmarking practices, i.e. the circularity and closed loop applications concepts, as well as fact-based methods for evaluation.



WHAT IS RECYCLABILITY?

THE PRODUCT MUST BE MADE WITH PLASTIC THAT IS COLLECTED FOR RECYCLING, HAS MARKET VALUE AND/OR IS SUPPORTED BY A LEGISLATIVELY MANDATED PROGRAM

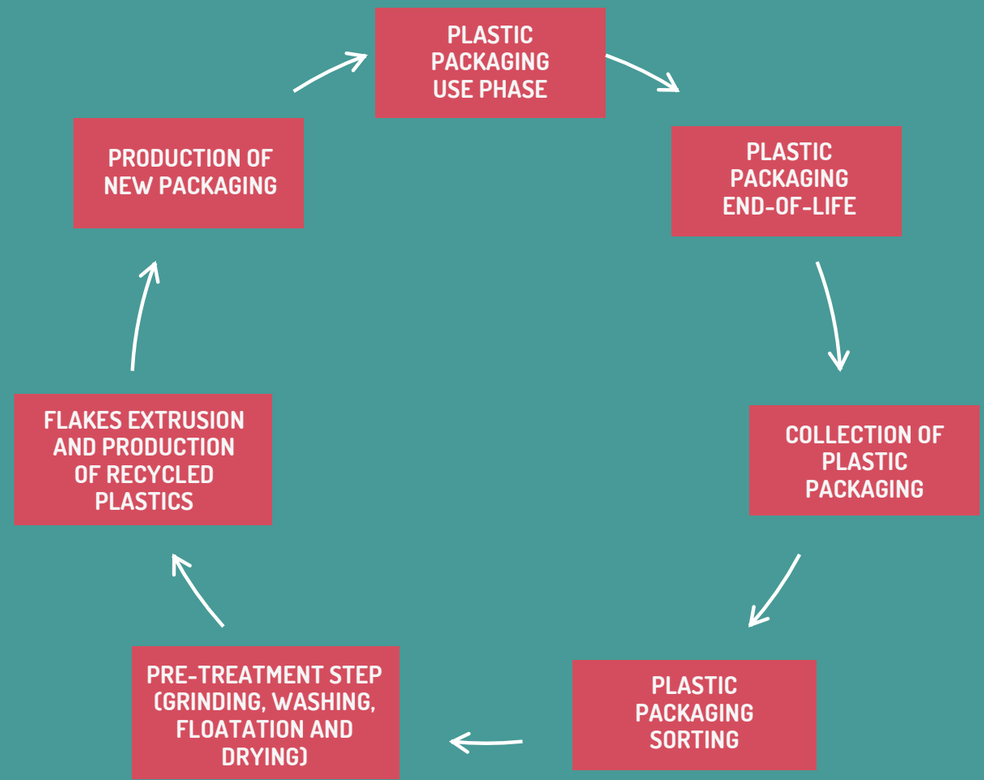
THE PRODUCT MUST BE SORTED & AGGREGATED INTO DEFINED STREAMS FOR RECYCLING PROCESSES.

THE PRODUCT CAN BE PROCESSED & RECLAIMED/RECYCLED WITH COMMERCIAL RECYCLING PROCESSES.

THE RECYCLED PLASTIC BECOMES A RAW MATERIAL THAT IS USED IN THE PRODUCTION OF NEW PRODUCTS.

RecyClass defines a plastic packaging as recyclable when the 4 criteria are fulfilled. In practice, design of plastic packaging will not only determine its ability to be collected and sorted in appropriate streams but will also impact the quality of recycling process and the recyclates produced. The industry must, therefore, ensure the circularity of packaging is safeguarded from the first steps of the product's lifecycle.

RECYCLASS VISION OF PLASTIC PACKAGING CIRCULARITY



CIRCULARITY – THE ULTIMATE GOAL

In line with the fourth requirement of the recyclability definition, RecyClass endorsed the concept of circularity as defined by Ellen Mac Arthur Foundation[1]. The notion of plastics circularity is dependent on material circulation, where packaging re-enters the economy in packaging applications for as long as possible.

CLOSED-LOOP APPLICATIONS – THE BENCHMARK

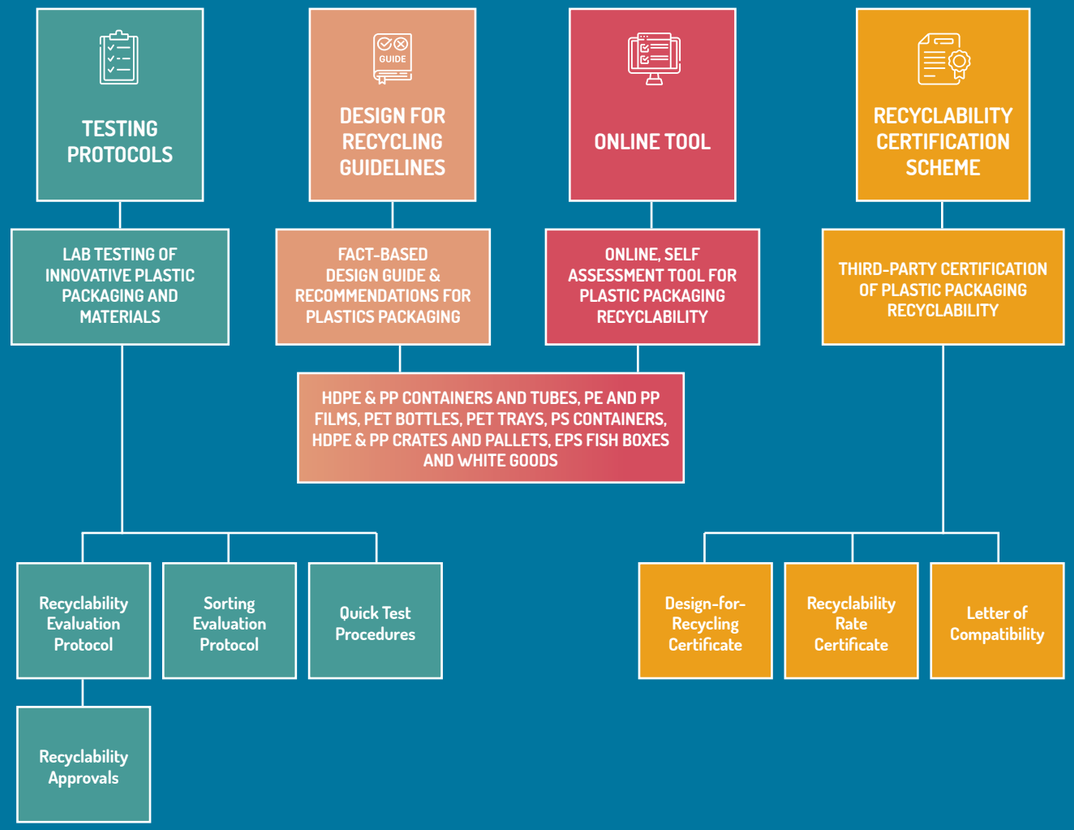
Closed-loop applications are used as benchmark for RecyClass Testing Protocols and Design for Recycling Guidelines. However, there are cases where functionality requirements make certain packaging hard to be designed for closed-loop recycling systems. In those cases, design choices leading to the longer multiple-step cascaded recycling must be favoured to open loop recycling.

1. Ellen MacArthur Foundation: https://ellenmacarthurfoundation.org/

FACT-BASED APPROACH TO RECYCLABILITY

Through collaboration with various value-chain stakeholders, RecyClass established a scientific, fact-based approach to assess and certify plastic packaging recyclability. This approach is detailed in the RecyClass Methodology[2], which aims to create a positive environment, fostering innovation while making plastics fully circular.

The different elements are interlinked, creating coherent and transparent means of evaluating packaging recyclability. Findings generated via the laboratory testing of technologies and products are used as the basis for the information presented in the Design for Recycling Guidelines. Subsequently, the information is imported also in the RecyClass Online Tool[3], a self-assessment tool for the evaluation of plastic packaging recyclability. Finally, the Guidelines are used as reference for the Recyclability Certifications.



2. RecyClass Methodology: https://recyclass.eu/recyclability/methodology/
3. RecyClass Online Tool: https://recyclass.eu/recyclability/online-tool/

SCHEMATIC OVERVIEW OF THE RECYCLASS METHODOLOGY

According to the RecyClass Methodology, recyclability assessment consists of multiple evaluation steps, as explained in the table below. The Methodology promotes high standards which are pivotal in improving the quality of waste to ultimately close the loop.

1. SUITABILITY

ENSURE THAT PACKAGING BELONG TO PLASTIC STREAM, AND DO NOT CONTAIN ANY MAIN DISQUALIFIERS.

Main disqualifiers:
- < 50% of plastic
- < 50% plastic surface
- Bio or oxo degradable additives
- Aluminium layer >5µm
- Surface containing carbon black

2. PRE STREAM

VERIFY THAT A RECOGNIZED PRE RECYCLING STREAM EXISTS FOR THE PACKAGING.

PRE recognized streams:
- Clear/light blue & transparent coloured PET bottles
- Clear PET trays
- PE flexible films
- PP flexible films
- HDPE containers
- PP containers
- PS containers
- HDPE & PP crates & pallets
- EPS fish boxes
- EPS white goods

3. RECYCLABLE PLASTIC CONTENT

CALCULATE THE AMOUNT OF RECOVERABLE AND VALUABLE PLASTIC FOR THE TARGETED RECYCLING STREAM.

- Class A: > 95 %
- Class B: 90-95 %
- Class C: 70-90 %
- Class D: 50-70 %
- Class E: <50 %

4. SORTABILITY

ANALYSE THE SORTABILITY BASED ON CRITERIA (LARGE LABELS, BODY SLEEVES, MULTI-LAYER...) AND TEST THE SORTING EFFICIENCY IN AN OPERATIONAL SORTING PLANT FOLLOWING RECYCLASS SORTING PROTOCOL.

0 penalty:
- efficiency >80% and <10% contamination

-1 class:
- efficiency>80% and <10% contamination
- efficiency 70-80% and <10% contamination

-2 classes:
- efficiency 70-80% and > 10% contamination
- efficiency 50-70% and <10% contamination

-3 classes:
- efficiency 50-70% and >10% contamination

Disqualified:
- efficiency 50-70% and >20% contamination
- effciency < (0%)

5. DFR INCOMPATIBILITIES

ENSURE ALL MATERIALS AND COMPONENTS (INKS, LABELS, ETC.) OF PACKAGING ARE COMPATIBLE WITH DESIGN FOR RECYCLING PRINCIPLES, TO PROVIDE HIGH QUALITY RECYCLED PLASTIC. BASED ON THE RECYCLASS DESIGN RECYCLING GUIDELINES.

Design for Recycling incompatibilities are separated under two categories:
- 5a. Removable materials and components
- 5b. Non-removable materials and components

Testing protocols can be conducted to verify the compatibilities of all or certain packaging features with recycling.

6. EASY TO EMPTY INDEX (EtEi)

ASSESS THE PACKAGING IS EASILY ACCESSIBLE AND EMPTIED, SO THAT MINIMUM RESIDUES POLLUTE THE RECYCLING STREAM.

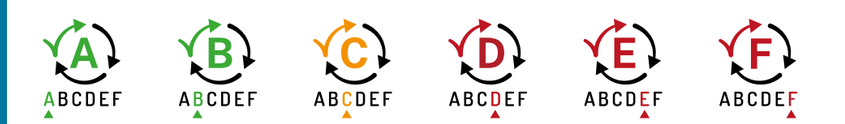
Residual product content < weight of packaging/2
No penalty: EtEi < 5
- 1 class: EtEi < 10
- 2 classes: EtEi < 15
etc.

7. COMPLIANCE

CHECK THAT THE PACKAGING COMPLIES WITH REACH REGULATION, MEANING THAT ANY SUBSTANCES OF VERY HIGH CONCERN ARE NOT ADDED TO THE PACKAGING.

The subtances are identified in the list of Substances of Very High Concern (SVHCs).

- 3 classes : if there is a SVHC



DESIGN FOR RECYCLING GUIDELINES

GENERAL PRINCIPLES

Design for recycling offers insight into how different components of a plastic packaging must be designed and assembled to be compatible with recycling. It considers components such as caps, labels, and additives, as well as their behaviour in a given recycling stream.

KEY PRINCIPLES OF RECYCLASS DESIGN FOR RECYCLING

CHOOSE PLASTICS THAT HAVE A RECYCLING STREAM IN EU

- Rigid packaging: HDPE, PP, PS and PET bottles & trays
- Flexible packaging: PE and PP

MAXIMISE THE PROPORTION OF THE MAIN POLYMER

- Recycling processes vary depending on polymers types, thus the use of components made of different polymers should be minimised.

FAVOUR MONO-MATERIAL SOLUTIONS

- Combination of various types of plastic may complicate both the sorting and the recycling steps.

REDUCE COLORS AND PRINTING

- Colours and printing cannot be removed during recycling.
- This reduces the visual aspect and quality of the recyclate.

ENABLE CONSUMERS TO EMPTY THE PACKAGING ENTIRELY

- Large amount of product residues after normal use-phase of the packaging creates added contamination during recycling and resuls in extra water-treatment steps.

With these general principles in mind, RecyClass developed detailed Design for Recycling Guidelines[4] for each type of packaging, providing a more in-depth guidance for the plastic industry.

4. RecyClass Design for Recycling Guidelines: https://recyclass.eu/recyclability/design-for-recycling-guidelines/

HOW TO READ THE GUIDELINES?

Design for Recycling Guidelines advise users on how to improve the overall technical recyclability of products when designing the packaging. They provide information, per packaging type, on which combinations of materials work best and which should be avoided to safeguard the circularity of plastic materials.

Guidelines present fact-based information as technologies or polymers presented in the Design for Recycling Guidelines have previously been tested to assess compatibility levels or are well known to the plastics recycling industry. Additionally, to stay in line with latest market developments and broaden the knowledge among industry players, the Guidelines are continuously updated with new findings.

RecyClass

1 Natural HDPE Containers and Tubes

		YES - FULL COMPATIBILITY	CONDITIONAL - LIMITED COMPATIBILITY	NO - LOW COMPATIBILITY
	MATERIAL COMPOSITION (AMOUNT OF **PE & PP ATTACH** IN THE PACKAGING) **2**	**A > 95%, B > 90% and all packaging features are FULLY compatible with recycling**	**C > 70% and all packaging features are FULLY compatible with recycling**	**D > 50%, E > 30%, F < 30% and all packaging features are FULLY compatible with recycling**
	DESCRIPTION (TEST PROTOCOL)	**Materials that passed the testing protocols with no negative impact OR materials that have not been tested (yet), but are known to be acceptable in PE recycling**	**Materials that passed the testing protocols if certain conditions are met OR materials that have not been tested (yet), but pose a low risk of interfering with PE recycling**	**Materials that failed the testing protocols OR materials that have not been tested (yet), but pose a high risk of interfering with PE recycling**
	DESCRIPTION (METHODOLOGY)	**In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from A to B or from B to C**	**In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from C to D**	**In case of at least one limited compatibility one penalty is applied, lowering the recyclability class from D to E or from E to F**
MAIN BODY	MATERIAL *	**HDPE; Multilayer PE with HDPE prevalence (LLDPE, LDPE, MDPE)**		**Multilayers HDPE with PLA; PVC; PS; PET; PETG**
	COLOURS **3**	**Natural (clear)**	**Light colours**	**Black Inner layer; Black; Carbon Black; Other dark colours**
	SIZE		**Items compacted < 5 cm**	**Items compacted < 2 cm**
	PRODUCT RESIDUES (EASY TO EMPTY INDEX)	**A if the index is < 5%; B if the index is < 10%**	**C if the index is < 15%**	**D if the index is < 20%; E < if the index is 25%; F if the index is > 25%**
	BARRIER	**EVOH < 6,0%wt + PE-g-MAH tie layers with MAH > 0.1%wt and EVOH:tie layers ratio < 2; Enkase (fluorination)**	**EVOH > 6,0%wt + PE-g-MAH tie layers with MAH > 0.1%wt and EVOH:tie layers ratio < 2; EVOH < 1% with any other tie layers**	**EVOH > 1% with any other tie layers; PA; PVDC; Aluminium**
	ADDITIVES	**Additives that are unavoidable in processing (stabilizers, antio… bricants, nucleating agents, peroxides) and density remains < 0,97 g/cm³ 4**	**Mineral fillers (CaCO3, talc) not increasing density more than 0,97 g/cm³**	**Additives changing the material density > 1 g/cm³; Flame-retardant additives, plasticizers; Bio-/oxo-/photodegradable additives**
ATTACHMENTS	CLOSURE SYSTEM	**HDPE; LDPE; LLDPE; MDPE**	**PP; PET; PETG; PLA; PS (all with a density > 1 g/cm³); Removable aluminium lidding**	**Non-PO and/or foams with density < 1 g/cm³; Aluminium; Metal; PVC**
	LINERS, SEALS AND VALVES	**HDPE; LDPE; LLDPE; MDPE; TPE-PE**	**PP; TPE-PP; PET, PETG, PLA, PS (all with a density > 1 g/cm³); Removable silicon with a density > 1 g/cm³**	**Non-PO and/or foams with density < 1 g/cm³; Any other TPE; Aluminium; Metal; Foiled paper; PVC**
	OTHER COMPONENTS	**HDPE, LDPE, LLDPE, MDPE**	**PP; PET; PETG; PLA; PS all with density > 1 g/cm³**	**Aluminium; PVC; Glass components; Foams with density < 1 g/cm³**
DECORATION**	INKS	**Non toxic following the EuPIA Guidelines**		**Inks that bleed; Toxic or hazardous inks; PVC binders**
	LABELS MATERIALS (PSL, WET-GLUE LABELS, WRAP-AROUND LABELS, IML)	**Labels in PE (all with density < 1 g/cm³)**	**Labels in PP, PO (with density < 1 g/cm³); Labels in PET, PETG, PLA, PS (all with density > 1 g/cm³); Labels in Paper without fibreloss; PO-foamed labels**	**Labels that hinder the recognition of the PE; Labels in non PO-materials with density < 1 g/cm³; Paper labels with fibreloss during recycling process; In-Mould-Labels; Aluminium; Metallised labels; PVC**
	ADHESIVES FOR LABELS	**Water soluble adhesive (@ less than 40°C); Water releasable adhesive (@ less than 40°C)**		**Non-water soluble adhesive (@ less than 40°C); Non-water releasable adhesive (@ less than 40°C)**
	SLEEVES	**Sleeves in PE (all with density < 1 g/cm³); Self-separable plastic and cardboard sleeves under mechanical pressure (sorting test mandatory)**	**Sleeves in PO (with density < 1 g/cm³); Sleeves in PET, PETG, PET-C, PLA, PS (all with density >1 g/cm³); Cardboard sleeves without fibreloss (sorting test mandatory)**	**Sleeves that hinder the recognition of the PE; Sleeves in non PO-materials with density < 1 g/cm³; Cardboard sleeves with fibreloss during recycling process; Aluminium; Metallised sleeves; Heavily inked sleeves; PVC**
	DIRECT PRINTING	**Laser marked; Production or best-before date**		**Any other direct printing**
	OTHER DECORATIVE TECHNOLOGIES		**Electroplating on attachments (with density > 1 g/cm³)**	**Electroplating on attachments (with density < 1 g/cm³)**

5 **RECYCLED CONTENT**: No change in the recyclability assessment. A separate "Recycled Plastics Traceability Certification" based on a Chain of Custody approach is available with RecyClass

* Polymer resin can be either fossil- or bio-based, virgin or recycled.

** Decorative technologies must not hinder the recognition of the underlaying PE-polymer. Features as size, print, mass colouration and/or barrier might require to perform a Sorting Evaluation Protocol. Known misleading features are listed on the RecyClass Methodology and the following size indications can be considered to ensure the recognition of PE:

- Size of non-PE detectable surfaces on containers > 500 ml: < 70% coverage
- Size of non-PE detectable surfaces on containers < 500 ml: < 50% coverage

6

Last update: Dec. 2021 **7**

Example of RecyClass Design for Recycling Guidelines

1. PACKAGING TYPE

Each Design for Recycling Guideline refers to a specific recycling stream available in Europe. Three parameters are considered for a guideline:

- The nature of the polymer: HDPE, PP, PET, PS, etc.
- The form of the packaging: containers, tubes, flexibles, trays, etc.
- The colour of the packaging: natural (clear) or coloured

2. LEVELS OF COMPATIBILITY

The RecyClass Guidelines are based on a traffic-light system.

- Green indicates the preferred design features that guarantee the best technical recyclability and are suitable with closed-loop recycling systems such as “bottle to bottle” or “film to film”.
- Yellow column lists packaging features that have passed the Recyclability Evaluation Protocols under specific conditions, or are known to have a limited impact on recycling but are compatible with it.
- Red column houses features that strongly downgrade or disqualify fully packaging recyclability. These features can lead to sorting issues, contamination of recycling streams or degradation of materials along the process.

3. PACKAGING COMPONENTS / FEATURES

The Guidelines look to packaging components known to have an impact on the packaging recycling process. If a feature is not covered by the Guidelines, it means that its recyclability has yet to be evaluated and tested.

4. LABORATORY FINDINGS

Hyperlinks to the related Recyclability Approval Letters with more information about the conditions associated with the use of the corresponding technology are included in the Guidelines.

5. RECYCLED CONTENT

RecyClass Design for Recycling Guidelines focus only on the compatibility of plastic packaging with recycling. Use of recycled content does not impact recyclability, instead it should be assessed with a separate method evaluating its traceability and its origin.

6. FOOTNOTES

Footnotes clarify specific classifications or inform users about ongoing testing campaigns by RecyClass Technical Committees.

7. VERSION TRACKING

The Guidelines are living documents, as they are continuously updated by plastics value chain experts based on new scientific findings.

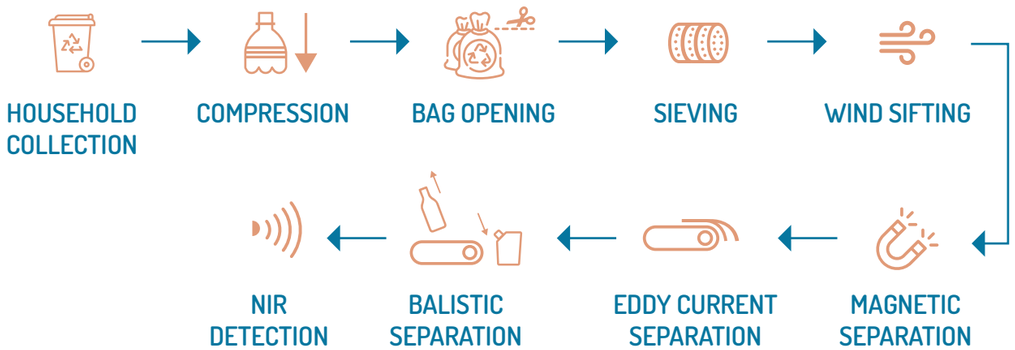
MINIMUM REQUIREMENTS FOR DESIGN FOR RECYCLING

Composition and compatibility of packaging features, and more specifically their recyclability, are highlighted during the different steps of the waste management process.

As the recyclability definition stipulates, the packaging must first be made of a plastic for which collection systems are set in place. Subsequently, the behaviour of the packaging and its components throughout the sorting and recycling processes will determine its overall recyclability.

Within this section, the different process steps are portrayed with a focus on the impact that the packaging design has.

SORTING PROCESS



HOUSEHOLD COLLECTION
Packaging is collected via locally established waste collection schemes, which vary across Europe. Information on available collection schemes can be found via the RecyClass Online Tool.

COMPRESSION
After collection, waste is compacted before arriving to the sorting centre. During this step, different components of a packaging could detach due to mechanical stress.

SIEVING
During sieving, items are sorted by size. Typically, one-dimensional items smaller than 5cm are discarded and sent for incineration.

WINDSIFTING
Airflow sucks up light-weight materials and separates them from heavier material. To optimise the quality of the recycling streams, it is recommended not to mix light and heavy materials together.

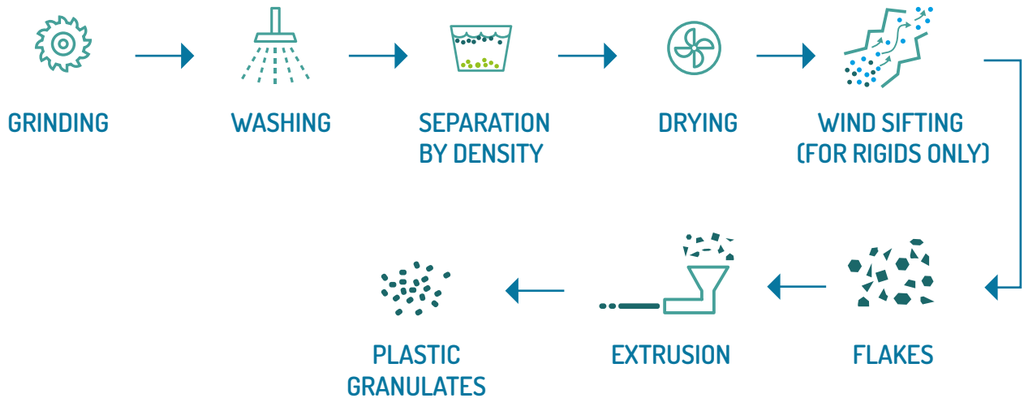
MAGNETIC SEPARATION
At this stage, the presence of ferro-metals in the packaging is checked. Plastic packaging containing metallic components will either be sent to the metal recycling stream, leading to material losses, or remain in the plastic stream and highly pollute the output material.

EDDY CURRENT SEPARATION
Non-ferrous metals are addressed in this step, for example aluminium. A plastic package with a thick aluminium layer will be sent to the aluminium recycling stream, and the material will be lost.

BALISTIC SEPARATION
Rigid (3D) and flexible (2D) packaging is separated at this stage. This step is particularly important for pouches or tubes which can be considered either as rigid or flexible packaging.

NIR DETECTION
Both rigid and flexible packaging is further sorted via Near Infra-Red (NIR) detection, which sorts packaging according to polymer types, and for more refined streams, by colours. This step is crucial to guarantee the quality of the final recyclate. To ensure highest efficiency of detection, packaging made of a combination of several material types or different plastic types should be avoided. Large labels or sleeves, excessive use of printing or pigments can also impact the efficiency of NIR detection.

RECYCLING PROCESS



GRINDING
Packaging is shredded to obtain plastic flakes.

WASHING
Flakes are washed to reduce contamination from product residues. Ensuring that packing is easy to empty[5] of residuals is essential in limiting contamination. During this step, labels using water-soluble adhesives are removed. Moreover, bleeding inks can contaminate the washing water, leading to extra-costs for the treatment of contamination. Quick Test Procedure for bleeding inks[6] was developed by RecyClass, enabling companies to easily evaluate the behaviour of their inks. Good design practices for inks also include compliance with the EuPIA exclusion policy.[7]

SEPARATION BY DENSITY
Within water baths, materials are be separated according to their density based on the sink-float principles. Each polymer has its own intrinsic density, enabling for its proper separation. However, use of certain fillers, foams or other additives can modify the density of a given polymer and therefore lead to losses of materials or downgrading of recyclates quality.

DRYING
Flakes are dried to avoid high moisture content which can degrade the material during the extrusion process.

WIND SIFTING
For rigid packaging, this air elutriation step enables to separate the fines and the flexible items (sleeves, detached labels, etc.).

EXTRUSION
Flakes are melted and mixed during extrusion, to obtain plastic pellets. At this stage, certain components can degrade the quality of the output material. These include polyvinyl chloride (PVC) and polyvinylidene chloride (PVDC) which contain chlorine that reacts with recycling temperatures, causing degradation, or bio- and oxo-degradable materials (PLA, PHA, starch) that promote breakage and lower the recyclates quality.

PLASTIC GRANULATES
At the end of the recycling process, recycled plastic pellets, or recyclates, are obtained. This material is then used to produce new items or packaging. Additionally, packaging must be designed in compliance with REACH regulation, ensuring no presence of substances of very high concern[8]. This guarantees not only the safety of packaging during the first use cycle, but also the safety of recyclates that will be produced from it.

Modules of the current recycling processes may vary depending on the recycled material, and recycling lines. Standardization process is under transition and will be facilitated with the development of more recyclable material, according to RecyClass Design for Recycling Guidelines.

5. Easy-to-Empty Index is an integral part of the RecyClass Methodology for the evaluation of plastic packaging recyclability. Companies can use the Online Tool to self-assess their performance.
6. Washing Quick Test Procedure for Bleeding Inks Printed on HDPE & PP Containers, PS Containers or PE & PP Films
7. EuPIA Exclusion Policy for Printing Inks and Related Products
8. The list of Substance of Very High Concerns (SVHCs) can be found here: https://echa.europa.eu/candidate-list-table.

HOW TO DESIGN RECYCLABLE PLASTIC PACKAGING?

Compatibility of packaging design features with recycling is essential for securing a smooth transition towards a circular plastics economy.

The higher the compatibility, the higher the recyclability of the given package will be, and ultimately it will enable the production of high-quality recycled plastics.

In this context, Design for Recycling Guidelines aid users in understanding the impact of different features on given recycling streams.

Currently, RecyClass Guidelines are available for 16 different packaging types and this section explores specific design recommendations for the main packaging groups.

HDPE AND PP NATURAL AND WHITE CONTAINERS

1. MAIN BODY OF PACKAGING

Ideally, packaging should be mono material. The larger the content of one polymer in the packaging, the higher its recyclability rate will be.

THIS RECOMMENDATION APPLIES TO ALL RIGID AND FLEXIBLE PACKAGING TYPES.

- ✓ *Full PE or PP*
- ~ *PE in PP up to 10 wt%, PP in PE up to 10 wt%*
- ✗ *Multilayer with PLA, PVC, PS, PET, PETG*

2. CLOSURE SYSTEMS

Staying consistent in the use of mono-material components improves recyclability, while avoiding any sorting issues or material losses. To a certain extent, PP caps are accepted on HDPE containers (and vice-versa), as well as materials that can be separated by density (PET, PS).

- ✓ *Same material as container*
- ~ *Other PO materials, other polymers with density > 1 g/cm³*
- ✗ *Aluminium, metal, PVC*

3. COLOUR

Presence of inks, pigments or coloured masterbatches impacts the visual aspect of recyclates (e.g.: colouration or black dots), thus lowering its economic value. Therefore, RecyClass promotes the separation of natural, white and coloured packaging into distinct recycling streams to preserve the quality of clear recyclates.

For packaging designed to enter natural or white stream, even light colouration is detrimental, while any dark colours are considered as disqualifying criteria.

- ✓ *Natural or white*
- ~ *Light colours*
- ✗ *Dark colours, black inner layer, non-NIR detectable colours*

4. BARRIER TECHNOLOGIES

Barrier layers protect contents from light, moisture, or gases, but they cannot be removed during the recycling process, directly affecting the recyclability. High amount of Ethylene Vinyl Alcohol (EVOH) stabilized by specific tie layers or even low quantities of EVOH without tie layers impede the recycling process.

- ✓ *<6wt% of EVOH with PE or PP-based tie layer, SiOx in PE*
- ~ *>6wt% of EVOH with PE or PP-based tie layer or <1wt% of EVOH without tie layer*
- ✗ *>1wt% of EVOH without tie layer, PVOH, PA*

5. ADHESIVES FOR LABELS

Water releasable or water-soluble adhesives ensure easy separation of labels from main packaging body (washing at 40°C without caustic soda). Labels that stay attached to packaging after the washing process can contaminate and lower the quality of final recyclates, especially if a label is not of same material as the container.

- ✓ *Releasable adhesives*
- ✗ *Non-releasable adhesives*

6. LABELS & SLEEVES

Labels and sleeves made of same materials as the main packaging body ensure it is properly detected during sorting steps and lower residue contamination of recyclates. Labels and sleeves made of other materials are acceptable if their coverage of packaging is limited and/or does not hinder the sorting process.

Use of paper labels is depended on fibre loss, the residues of which hamper recyclates quality.

- ✓ *Same materials as container, if separable*
- ~ *PP, PET, PS, paper (without fibre loss) labels/sleeves if separable (density > 1g/cm³)*
- ✗ *Labels/sleeves hindering the NIR detection, paper with fibre loss, non detachable PET labels*

7. INKS & DECORATIONS

As is the case for colours, it is recommended to limit the use of inks (especially dark inks) on packaging to improve the quality of recyclates. For natural or white packaging, the use of ink should be limited to only laser marks, production and best-before dates.

- ✓ *Laser marking or direct printing for production or best-before date*
- ✗ *Any other direct printing*

INFO BOX

The same design for recycling recommendations apply to natural and white plastic packaging, to preserve the high-value of these materials and to ensure the availability of both white and natural recycled plastic on the markets. However, natural and white packaging should be sorted into two distinct streams and recycled separately.

INFO BOX

RELEASABLE LABELS

To ensure that inks do not pollute the quality of the natural and white recycling streams, labels present on such packaging must be releasable to be considered compatible with recycling. Tests must be performed to ensure releasability. RecyClass has published a protocol to assess the releasability of labels from HDPE containers.

HDPE AND PP COLOURED CONTAINERS

1. MAIN BODY OF PACKAGING

Ideally, packaging should be mono material. The larger the content of one polymer in the packaging, the higher its recyclability rate will be.

THIS RECOMMENDATION APPLIES TO ALL RIGID AND FLEXIBLE PACKAGING TYPES.

- (+) *Full PE or PP*
- (~) *PE in PP up to 10 wt%, PP in PE up to 10 wt%*
- (X) *Multilayer with PLA, PVC, PS, PET, PETG*

2. CLOSURE SYSTEMS

Staying consistent in the use of mono-material components improves recyclability, while avoiding any sorting issues or material losses. To a certain extent, PP caps are accepted on HDPE containers (and vice-versa), as well as materials that can be separated by density (PET, PS).

- (+) *Same material as container*
- (~) *Other PO materials, other polymers with density > 1 g/cm³*
- (X) *Aluminium, metal, PVC*

3. COLOUR

For coloured packaging, all colours are accepted except non-NIR detectable pigments such as carbon black. It is recommended to use lighter colours in smallest proportions possible.

- (+) *Light colours*
- (~) *Dark colours, black inner layer*
- (X) *Non-NIR detectable colours*

4. BARRIER TECHNOLOGIES

Barrier layers protect contents from light, moisture, or gases, but they cannot be removed during the recycling process, directly affecting the recyclability. High amount of Ethylene Vinyl Alcohol (EVOH) stabilized by specific tie layers or even low quantities of EVOH without tie layers impede the recycling process.

- (+) *<6wt% of EVOH with PE or PP-based tie layer, SiOx in PE*
- (~) *>6wt% of EVOH with PE or PP-based tie layer or <1wt% of EVOH without tie layer, <1 wt% of PVOH in PE, metallisation*
- (X) *>1wt% of EVOH without tie layer, >1 wt% of PVOH in PE, PA*

5. ADHESIVES FOR LABELS

Water releasable or water-soluble adhesives ensure easy separation of labels from main packaging body (washing at 40°C without caustic soda). Labels that stay attached to packaging after the washing process can contaminate and lower the quality of final recyclates, especially if a label is not of same material as the container.

- (+) *Releasable adhesives*
- (X) *Non-releasable adhesives*

6. LABELS & SLEEVES

Labels and sleeves made of same materials as the main packaging body ensure it is properly detected during sorting steps and lower residue contamination of recyclates. Labels and sleeves made of other materials are acceptable if their coverage of packaging is limited and does not hinder the sorting process.

Use of paper labels is depended on fibre loss, the residues of which hamper recyclates quality.

- (+) *Same materials as container*
- (~) *PO (density < 1 g/cm³); PET, PS, paper (without fibre loss) labels/sleeves if separable > 1 g/cm³*
- (X) *Labels/sleeves hindering the NIR detection, paper with fibre loss, non detachable PET labels*

7. INKS & DECORATIONS

It is recommended to limit the use of inks (especially dark inks) on packaging. All inks must be compliant with the EuPIA-exclusion policy, while PVC & PVDC binders are prohibited.

- (+) *Direct printing representing <1wt% of the total packaging*
- (~) *Direct printing*
  Cold transfer and hot stamping
- (X) *Printing hindering the NIR-detection*

8. LAMINATING ADHESIVES

Some rigid packaging like tubes can contain laminating adhesives. In this regard, recommendations available for PE and PP films were extended to rigid packaging.

- (+) *< 3 wt% PU and water-based acrylics*
- (~) *3 to 5 wt%*
- (X) *> 5 wt%, epoxy, etc.*

PS NATURAL AND WHITE CONTAINERS

1. MAIN BODY OF PACKAGING

Foamed PS is not compatible with the PS recycling stream due to the difference of density (< 1 g/cm³)

⊕ *PS*

⊗ *Multilayer, Foamed PS*

2. CLOSURE SYSTEMS

Staying consistent in the use of mono-material components as much as possible increases the amount of recycled material while avoiding any sorting issues or material losses. To a certain extent, polyolefin and paper closures are accepted on PS containers since they will be removed by density before recycling.

⊕ *PS*

~ *Removable PE, PP*
Removable aluminium
Removable PET

⊗ *Metal, PVC*

3. COLOUR

Presence of inks, pigments or coloured masterbatches impacts the visual aspect of recyclates (e.g.: colouration or black dots), thus lowering its economic value. Therefore, RecyClass promotes the separation of natural, white and coloured packaging into distinct recycling streams to preserve the quality of clear recyclates.

For packaging designed to enter natural or white stream, even light colouration is detrimental, while any dark colours are considered as disqualifying criteria.

⊕ *Natural or white*

⊗ *Any other colours*

4. BARRIER TECHNOLOGIES

The impact of barrier technologies on recyclability of PS containers still needs to be investigated.

⊕ *< 5 wt% of EVOH with PE*

~ *> 5 wt% of EVOH with PE-based tie layer or*
<1wt% of EVOH without tie layer

⊗ *>1wt% of EVOH without tie layer*

5. ADHESIVES FOR LABELS

Water releasable or water-soluble adhesives ensure easy separation of labels from main packaging body (washing at 40°C without caustic soda). Additionally, it is important to separate labels that are made from a different plastic or grade in order to avoid any further contamination.

⊕ *Releasable adhesives*

⊗ *Non-releasable adhesives*

6. LABELS & SLEEVES

Labels and sleeves made of same materials as the main packaging body ensure it is properly detected during sorting steps and lower residue contamination of recyclates. Labels and sleeves made of other materials are acceptable if their coverage of packaging is limited and does not hinder the sorting process.

Use of paper labels is depended on fibre loss, the residues of which hamper recyclates quality.

⊕ *PS if separable*

~ *PP, PE labels/sleeves if separable*

⊗ *Labels/sleeves hindering the NIR detection*
Paper
Non detachable PET labels

7. INKS & DECORATIONS

As is the case for colours, it is recommended to limit the use of inks (especially dark inks) on packaging to improve the quality of recyclates. For natural or white packaging, the use of ink should be limited to only laser marks, production and best-before dates.

⊕ *Laser marking or direct printing for production or best-before date*

⊗ *Any other direct printing*

INFO BOX

PS RECOMMENDATIONS

In general, guiding design principles for PS containers are similar to the one based on PE and PP, however the recycling compatibility of currently used barriers, additives or even adhesives must be further evaluated. Note that Design for Recycling Guidelines are also available for coloured PS.

INFO BOX

EPS FISH BOXES & WHITE GOODS (RECYCLING STREAM & GUIDELINES)

Today, fish boxes and white goods made of expanded polystyrene (EPS) are separately collected at origin in most European countries. This creates a stream that is currently used in the production of EPS or XPS insulation boards. EPS characteristics have historically made it more difficult to separate expanded polystyrene and extruded polystyrene foam from the flow of mixed plastics. However, tests are undergoing for the separation of this fraction from the mixed stream.

Design for Recycling Guidelines for EPS fish boxes and white goods were released by RecyClass at the end of 2021 to ensure consistent high efficiency of the recycling process and quality of the resulting recyclates.

Design of EPS packaging follows similar rules as PS, but few deviations exist. As EPS fish boxes and white goods are separately collected and do not generally undergo an automated separation step, it is very important that no extraneous material such as cardboard or wood components are included in the packaging, unless it is easy to separate. Lids should only be in EPS or PS, as well as any other attachments. Any label should be made of PS or designed to be peelable. Moreover, as paper labels are commonly used on fish boxes, it is important to avoid fibre losses during the washing and floatation steps.

PET TRANSPARENT BOTTLES

1. MAIN BODY OF PACKAGING

(+) *PET*

(X) *PLA, PVC, PS, PETG*

2. CLOSURE SYSTEMS

It is recommended to use polyolefin-based materials for PET bottle applications to ensure their separability. Polyolefin closures are recovered and recycled into the mixed polyolefin (MPO) recycling stream as by-products.

(+) *PE, PP with density < 1g/cm³*

(X) *Materials with density > 1g/cm³, welded closures*

3. COLOUR

PET bottles are classified as “transparent clear & light-blue” and “transparent coloured”, as end-market for PET recyclates are present only for transparent (coloured) bottles. For the “transparent coloured” stream, the use of the lightest possible colours is encouraged. Opaque, metallic or fluorescent colourations are not compatible with recycling due to the lack of existing streams.

(+) *Transparent light blue or clear*

(X) *Other transparent colours*

4. BARRIER TECHNOLOGIES

Barrier for UV, moisture or gas resistance are often used in the design of PET bottles; however they might affect PET recycling by modifying mechanical or optical properties. The use of clear plasma coating is recommended if a barrier is needed.

(+) *SiOx plasma coating*

(~) *Carbon plasma-coating; PA-MXD6 combinations with < 5 wt%*

(X) *Multilayers with EVOH or PA-MXD6*

5. ADHESIVES FOR LABELS

Labels and adhesives applied on PET bottles must be detachable during the washing step to avoid contamination of the stream. Therefore, adhesives must be water soluble or water releasable at 65-80°C, with caustic soda, without any residue left on the bottle. Any other types of adhesives are not compatible with PET-bottles recycling.

(+) *Alkali/water releasable adhesive at 70-90°C*

(X) *Alkali/water soluble adhesive; alkali/water non-releasable adhesive at 70-90 °C*

6. LABELS, SLEEVES MATERIAL & TAMPER EVIDENCE WRAP

PET and PETG sleeves or labels disqualify PET bottles for recyclability due to the difference of polymer grade and the printing which degrade the quality of recycled PET and its food-contact behaviour. Floatable polyolefin-based plastics are encouraged and can be recycled into the (MPO) recycling stream as by-products.

(+) *PE, PP, (density <1g/cm³)*

(~) *Lightly metallised labels, foamed PET and paper labels without fiber losses*

(X) *Labels/sleeves hindering the NIR detection, materials with density >1g/cm³, non detachable labels, paper labels with washable inks*

7. INKS & DECORATIONS

Inks are detrimental for food-contact compliance, as they may induce non intended added substances (NIAS). Therefore, any direct printing is forbidden on PET-bottles and only laser marker printing is tolerated. Printing should be applied only on label or sleeve, that will get separated during the recycling process.

(+) *Retentive inks; inks applied on removable labels/sleeves; laser marking for production and expiry dates*

(~) *Production or expiry date (direct printing)*

(X) *Bleeding inks; metallic and washable inks; any other direct printing*

GENERAL INFORMATION

Transparent PET bottles are sorted separately (sometimes collected separately too) because of their high economic value, and therefore benefit from a more extensive recycling process (e.g., hot washing step with caustic soda), compliant with the food-contact regulations.

Key design characteristic for any additional packaging features – such as labels, sleeves, inks, closures – is its separability from the main body. Therefore, PO components are generally preferred to complete a PET bottle design.

The floating fraction of the PET bottles recycling stream is recovered and recycled into the MPO recycling stream.

INFO BOX

PET BOTTLE STREAMS

While this page refers to general recommendations for PET transparent bottles, it is important to keep in mind that clear/light blue, and colored transparent bottles are different streams. Design should always enable clear transparent bottles to be recycled into new clear transparent bottles. Guidelines for opaque PET bottles will soon be available.

PET bottle streams include:

- **Transparent clear / light-blue PET bottles**
- **Transparent coloured PET bottles**
- **Opaque PET bottles (under construction)**
- **Opaque white PET bottles (under construction)**

CLEAR PET TRAYS

1. MAIN BODY OF PACKAGING

- ✓ *PET (thickness > 180 micron)*
- ~ *PET/PE multilayer with or without barrier not hindering NIR detection of the PET*
- ✗ *PLA; PVC; PS; PETG*

2. LIDDING FILMS

The use of unprinted PET film remains the optimal option, while PO films without glue residues left on the PET thermoform and foamed PET films with no structure change at 90°C are also compatible with recycling.

- ✓ *Films with density <1g/cm³ without glue residual*
- ~ *Unprinted PET or BOPET films; foamed PET*
- ✗ *Any other films*

3. COLOUR

- ✓ *Transparent clear*
- ✗ *Opaque, other transparent colours*

4. BARRIER TECHNOLOGIES

- ✓ *PET based oxygen scavenger not creating yellowing; SiOx and AlOx plasma for barrier on lid*
- ~ PET-based *oxygen scavenger with limited yellowing*
- ✗ *Barrier layers within the PET layer or in direct contact to PET layer; PA; any other barrier or oxygen scavenger*

5. ADHESIVES FOR LABELS, LIDS OR SOAKING PADS

Labels should be entirely removed without leaving any residual adhesives on the flakes.

- ✓ *Alkali/water soluble or alkali/water releasable at 70 °C'*
- ~ *Alkali/water soluble or alkali/soluble releasable partially at 70 °C*
- ✗ *Any other adhesives*

6. LABELS

Floatable polyolefin-based plastics are encouraged and can be recycled separately.

- ✓ *PE, PP (< 50 % coverage)*
- ~ *BPA-free paper labels without fibre loss (coverage > 50 % - sorting test needed)*
- ✗ *Plastic labels with density >1g/cm³; paper labels with fiber loss; non-floating paper labels*

7. INKS & DECORATIONS

- ✓ *Retentive inks applied on removable parts; laser marking for production or expiry date*
- ~ Production or expiry date
- ✗ *Bleeding inks; any other direct printing*

INFO BOX

PET TRAYS: CURRENT SITUATION IN EU (COLLECTION, SORTING, RECYCLING)

PET trays are not yet widely collected for recycling in a significant number of European regions. PET trays are often considered to contaminate PET bottle bales and affect the quality of the PET flake.

To ensure that PET trays are recycled, trays need to be sorted from PET bottles or collected separately. PET trays are currently only sorted for separate recycling in some areas within France, Netherlands, Spain, Germany, Italy, UK and/or not at industrial scale.

As the PET tray recycling market continues to grow, more countries in Europe are expected to expand their existing collection and sorting processes to increase output quantities of collected and sorted bales.

This may apply as well to other PET rigid packaging such as pots, blisters, tubs and cups.

CASE STUDIES

MONO-MATERIAL TUBE SOLUTIONS

Nowadays, many non-beverage bottles are replaced with tubes to reduce the amount of used materials and lower the carbon footprint. This shift is challenging for HDPE recyclers, as traditional closure systems are made of PP and tubes' closures represent a high percentage of the packaging (up to 40% of the total weight), leading to high contamination in the stream.

RecyClass tested more than thirty-five PE-based tubes following the HDPE Recyclability Evaluation Protocol to better understand the impact of this packaging on the recycling stream and to provide solutions to the market.

Of the tested tubes, the following technologies can be highlighted. These packaging innovations meet all technical, aesthetical, as well as all the recycling requirements.

- The final tube product designed by Neopac with an HDPE screwed cap, barrier properties and fully printed.
- The tube technologies designed by Albéa and Huhtamaki with an HDPE cap solution (screwed cap and flip-top cap) and barrier properties.

This illustration highlights key design features to consider when producing HDPE tubes that are fully compatible with recycling. Replacing PP caps with HDPE caps with the right MFI and using the right amounts of EVOH-barrier and direct printing (or even better removable decoration) will preserve the quality of the HDPE recyclate, allowing its use in new tubes.

9. RecyClass Recyclability Approvals: https://recyclass.eu/recyclability/approvals/

NATURAL PE AND PP FILMS

1. MAIN BODY OF PACKAGING

Flexible packaging can be subdivided into two categories depending on their structures: coextruded and laminated structures. While coextruded films contain several plastic layers assembled only using heat and pressure, laminated films require the presence of an adhesive to glue the different plastic layers. Therefore, coextruded structures are more favourable, as they can more easily follow the mono-material approach.

- ⊕ *Full PE or PP*
- ~ *Multilayer PE/PP with limited amount of contaminants (5 % PP for PE and 10 % PE for PP stream)*
- ⊗ *Any other polymers*

2. CLOSURE SYSTEM, LINERS, SEALS & VALVES

- ⊕ *Same material as the film*
- ~ *PE for PP films and vice-versa*
- ⊗ *Aluminium, PVC, PET, etc.*

3. COLOUR

Unpigmented material has the highest value for recycling as it ensures the clear/light colour of the final output. This, in turn, guarantees better quality and a wide-set of applications in which the recyclates can be used.

- ⊕ *Transparent clear*
- ~ *Light or translucent colours*
- ⊗ *Opaque, dark colours, other transparent colours*

4. INKS & DECORATIONS

Inks have to be avoided for transparent films.

- ⊕ *PU-based inks for PE films*
  Printed production or expiry date
- ~ *Printing coverage <50%*
- ⊗ *NC binders; bleeding inks*
  Printing coverage >50%

5. BARRIER TECHNOLOGIES

The main barriers used in PE and PP flexible packaging are Polyamide (PA), EVOH, metallisation and PVOH. The use of EVOH substances is conditional as this functional barrier is thermally unstable compared to polyolefins and may quickly degrade during the extrusion phase, impacting the colour of recyclates (yellowing effect).

Other barriers must be further investigated. RecyClass conducts studies on barriers (e.g. metallisation and coatings) to generate data and increase the knowledge of barrier compatibility.

- ⊕ *AlOx & SiOx (without primer)*
- ~ < 5 wt% EVOH
- ⊗ *Any other PA, EVOH > 5 %, PVC, etc.*

6. LAMINATING ADHESIVES

Laminated structures are characterized by the presence of laminating adhesives that can be very complex. Many laminating adhesives tend to yellow the recyclate due to thermal degradation, which limits their recognition for the transparent stream.

- ⊕ *Laminating adhesives approved as fully compatible*
  Aliphatic PU with < 2.5 wt% for PE and < 2.3 wt% for PP'
- ~ *Water-based acrylics < 2.5wt%*
- ⊗ *Aromatic PU, water-based acrylics > 2.5 wt%, epoxy, etc.*

7. ADHESIVES FOR LABELS

Adhesives must be water releasable (at a temperature of 40°C). It is important to remove the adhesives at the washing stage as they can disrupt recycling.

- ⊕ *Water soluble and releasable at less than 40°C*
- ⊗ *Non soluble or releasable at 40°C*

8. LABELS

Paper labels generate fibres when washed, which then leads to black specks in recyclates.

- ⊕ *Same material as the film*
- ~ *PE for PP films and vice-versa*
- ⊗ *Metallised labels, paper labels*

INFO BOX

LAMINATED STRUCTURES: CURRENT STATE OF THE ART

Laminating adhesives used in laminated structures can be based on different chemistries such as polyurethane, UV-sensitive acrylates, or acrylic emulsions, but can also be water-based, solvent-based or even solvent-free. Despite the relatively low amount of adhesive in a film structure, many parameters such as the adhesive chemistries, performance level of the adhesive, and the combination with some barriers or inks can affect the recyclability of the packaging. Indeed, the complexity of laminating adhesives chemistry may allow them also to interact with other packaging features such as barrier or inks during the recycling process. Thus, investigations are ongoing using the Recyclability Evaluation Protocol for films to assess the compatibility of laminating adhesives depending on their structure and environment.

COLOURED PE AND PP FILMS

1. MAIN BODY OF PACKAGING

Flexible packaging can be subdivided into two categories depending on their structures: coextruded and laminated structures. While coextruded films contain several plastic layers assembled only using heat and pressure, laminated films require the presence of an adhesive to glue the different plastic layers. Therefore, coextruded structures are more favourable, as they can more easily follow the mono-material approach.

- (+) *Full PE or PP*
- (~) *Multilayer PE/PP with limited contaminants (5 % PP for PE and 10 % PE for PP stream)*
- (X) *Any other polymers*

2. CLOSURE SYSTEM, LINERS, SEALS & VALVES

- (+) *Same material as the film*
- (~) *PE for PP films and vice-versa*
- (X) *Aluminium, PVC, PET, etc.*

3. COLOUR

With dark colours, it is impossible to go back to light/semi-transparent colours (de-inking is not an established process). Dark colours (i.e. blue, red, green or black) can strongly affect the NIR detection efficiency due to partial or total light absorption.

- (+) *Light colours*
- (~) *NIR-detectable dark colours*
- (X) *Non NIR-detectable*

4. INKS & DECORATIONS

Inks must be limited as much as possible for coloured films, as they can cause the discolouration of the recycled material. Whenever used, they must comply with the EuPIA recommendations.

- (+) *PU-based inks (with no NC) and inks & varnish < 5 %, Laser marking with coverage < 50 %*
- (~) *< 0.8 % of NC-binders; inks & varnish 5-7 %; laser-marking with coverage > 50 %*
- (X) *> 0.8 % of NC binder; inks & varnish > 7 %; bleeding inks*

5. BARRIER TECHNOLOGIES

The main barriers used in PE and PP flexible packaging are Polyamide (PA), EVOH, PVOH and metallisation. The use of EVOH substances is conditional as this functional barrier is thermally unstable compared to polyolefins and may quickly degrade during the extrusion phase, impacting the colour of recyclates (yellowing effect).

Other barriers must be further investigated. RecyClass conducts studies on barriers (e.g. metallisation and coatings) to generate data and increase the knowledge of barrier compatibility.

- (+) *AlOx & SiOx (without primer)*
- (~) < 5 wt% EVOH, PVOH & soluble EVOH < 1 wt% with melt temperature < 225 °C for PE (to be investigated for PP); metallisation
- (X) *Any other PA, EVOH > 5 %, PVC, etc.*

6. LAMINATING ADHESIVES

Laminated structures are characterized by the presence of laminating adhesives that can be present complex chemistries. Several laminating adhesives tend to create gels within the recyclates due to poor melting/miscibility properties, which limits their compatibility with recycling.

- (+) *PU and WB acrylics up to 3 wt%, laminating adhesives approved as fully compatible*
- (~) *PU and WB acrylics between 3-5 wt% (to be investigated for PP)*
- (X) *Laminating adhesive specially developed for high thermal applications above boiling and/or for high chemical resistance (to be tested), epoxy, etc.*

7. ADHESIVES FOR LABELS

Adhesives must be water releasable (at a temperature of 40°C). It is important to remove the adhesives at the washing stage as they can disrupt recycling.

- (+) *Water soluble and releasable at less than 40°C*
- (X) *Non soluble or releasable at 40°C*

8. LABELS

Paper labels generate fibres when washed, which then leads to black specks in recyclates.

- (+) *Same material as the film*
- (~) *PE for PP films and vice-versa*
- (X) *Metallised labels, paper labels*

INFO BOX

PP FILMS: CURRENT SITUATION IN EU

Currently, the recycling of PP flexible packaging faces several limitations:

- **PP films are not collected in every European country;**
- **they do not tend to be sorted into a separate stream;**
- **due to a lack of reprocessing routes and lower presence in collected films streams, they are often considered as contaminants in film bales or are sorted into mixed plastic outputs.**

Therefore, it is important to point out that currently collection, sorting and recycling of PP flexibles remain insufficient and will need to be further developed.

Today, if recycled, such material will probably be in lower quality mixed polyolefin outputs.

Understanding commercial limitations for sorting and recycling of flexible PP packaging is important to unlock a new processing market and achieve increased recycling rates for flexible films.

CASE STUDIES

MONO-MATERIAL POUCH SOLUTIONS

Designing flexible packaging for recycling is often perceived as difficult, especially because of the thinness of the main material. Any foreign materials like inks, barriers, or laminating adhesives will immediately represent a significant percentage of the total structure.

The first step is always to replace multi-material structures with mono-material ones. Moreover, co-extruded structures are in general preferred by the recyclers as they are adhesive-free. However, by carefully choosing the type of laminating adhesive incorporated in the right amount, laminated flexibles can still be compatible with recycling as demonstrated by several tests conducted by RecyClass[13].

Among these tests, a pouch that stands out as a success story is:

- The mono-material laminated pouch designed by P&G for single-use laundry doses, that include a PE closure zipper[14] and is made of more than 95% of PE taking into consideration the laminating adhesive and the direct printing.

This illustration summarizes the key features to consider when designing LDPE flexible pouches that are fully compatible with recycling. Please note that rigid closures or components added on flexibles might modify the sorting behaviour of the packaging. A sorting test is strongly recommended for packaging mixing both rigid and flexible parts.

10. RecyClass Recyclability Approvals: https://recyclass.eu/recyclability/approvals/

HOW TO ACCELERATE THE TRANSITION TOWARDS CIRCULAR PLASTIC PACKAGING?

Circular future of plastic packaging depends on simultaneous improvements across each stage of a product's life cycle and along each step of the value chain – however, design is the first step to achieve that.

Today, lacking uptake of design for recycling principles results in low quality plastic waste and is therefore the biggest obstacle in achieving circularity. Companies must focus on the long-term objective – designing packaging that fulfils all technical and aesthetical requirements while safeguarding its recyclability.

As portrayed in this guide, the industry is on the good path to achieve plastics circularity, but the efforts must be further supported by value-chain collaboration, harmonisation and standardisation of waste management practices, as well as design for recycling principles, and continuous testing of existing and novel technologies.

The industry can look to the RecyClass Design Book as the first step in conceptualising plastic packaging designs. RecyClass offers additional tools for those who are willing to commit to further steps by either self-assessing packaging recyclability via the Online Tool or verifying it via independent third parties with RecyClass Recyclability Certifications.

Certified plastic packaging enables for reliable claims, building trust in the quality of products among customers, as well as consumers. Additionally, with various legislative targets, verification and certification are expected to bear more and more importance on the market.

With the comprehensive, fact-based approach and a set of various tools, RecyClass is a reliable reference for the industry for fully circular plastic packaging.

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