

DESIGN **4** RECYCLING

Designing plastic packaging
so it can be recycled

Introduction: Why Design4Recycling?

Packaging is a modern day jack-of-all-trades! It protects products and provides information for users. We don't usually keep it for very long, but it shouldn't just become waste because packaging contains finite resources and producing it consumes energy. When packaging is designed to be efficient, the raw materials used to make it can stay in circulation and be used again and again.

The recycling of products – particularly packaging – makes a significant contribution to protecting the climate from greenhouse gases and conserving resources. Such recycling requires the separate collection of sales packaging, which Der Grüne Punkt has promoted vigorously since 1990. Today, for the most part, collected packaging waste is sorted and recycled on an industrial scale in Germany.

» Design is crucial

A technical cycle can only be closed if the products used in it are recyclable. That means that the recyclable materials must be able to be clearly identified. And that's why packaging design is so important for packaging recyclability.

Small changes often significantly improve recyclability without negatively impacting the primary functions of the packaging. For a long time now, Der Grüne Punkt has been advising packaging manufacturers and bottlers about how to design packaging so that it can be recycled. The "Design4Recycling" service does not specifically advocate certain materials or processing options.

» Markets and technologies continue to develop

The purpose of this brochure is to help readers correctly assess recyclability, particularly with respect to packaging made from plastic, and to identify potential for improvement. Because the framework conditions are constantly changing due to market developments and technical advances, this design guide will be updated at non-specified intervals. The minimum standard of the Central Packaging Registry (ZSVR) is considered for the dimensioning of the recyclable design (bit.ly/2Nu3M5I).

» Support by Der Grüne Punkt

The experts of Der Grüne Punkt provide support and advice based on their extensive knowledge of the recycling infrastructure and many years of experience (www.design4recycling.de). Der Grüne Punkt's RecyclingCOMPASS (www.gruener-punkt.de/en/recyclingcompass) allows an initial online classification of packaging according to its specification.

» What makes recycling easier?

Depending on its purpose and how it is procured, packaging should be planned holistically. Among other characteristics, the following are beneficial for recycling:

- *Light colors (with plastic packaging)*
- *Mono-materials instead of a mix of materials*
- *Optimized label and closure solutions*
- *Components that can be separated in the recycling process*

The material profiles provided in this brochure should serve as guidelines. To evaluate specifically how well certain packaging can actually be sorted and recycled, each individual case must be examined.



High-quality regranulates for new packaging, e.g., flip-top caps, can be produced from optimally recyclable plastic packaging.

Sorting and recycling plastic packaging

Valuable expertise: Der Grüne Punkt has extensive knowledge of, and experience with, sorting and recycling technology. We are also familiar with the quality levels of secondary raw materials from the collection systems and the recycling market. This allows us to make substantiated statements regarding possible recycling processes for some types of packaging in light of “Design4Recycling.”

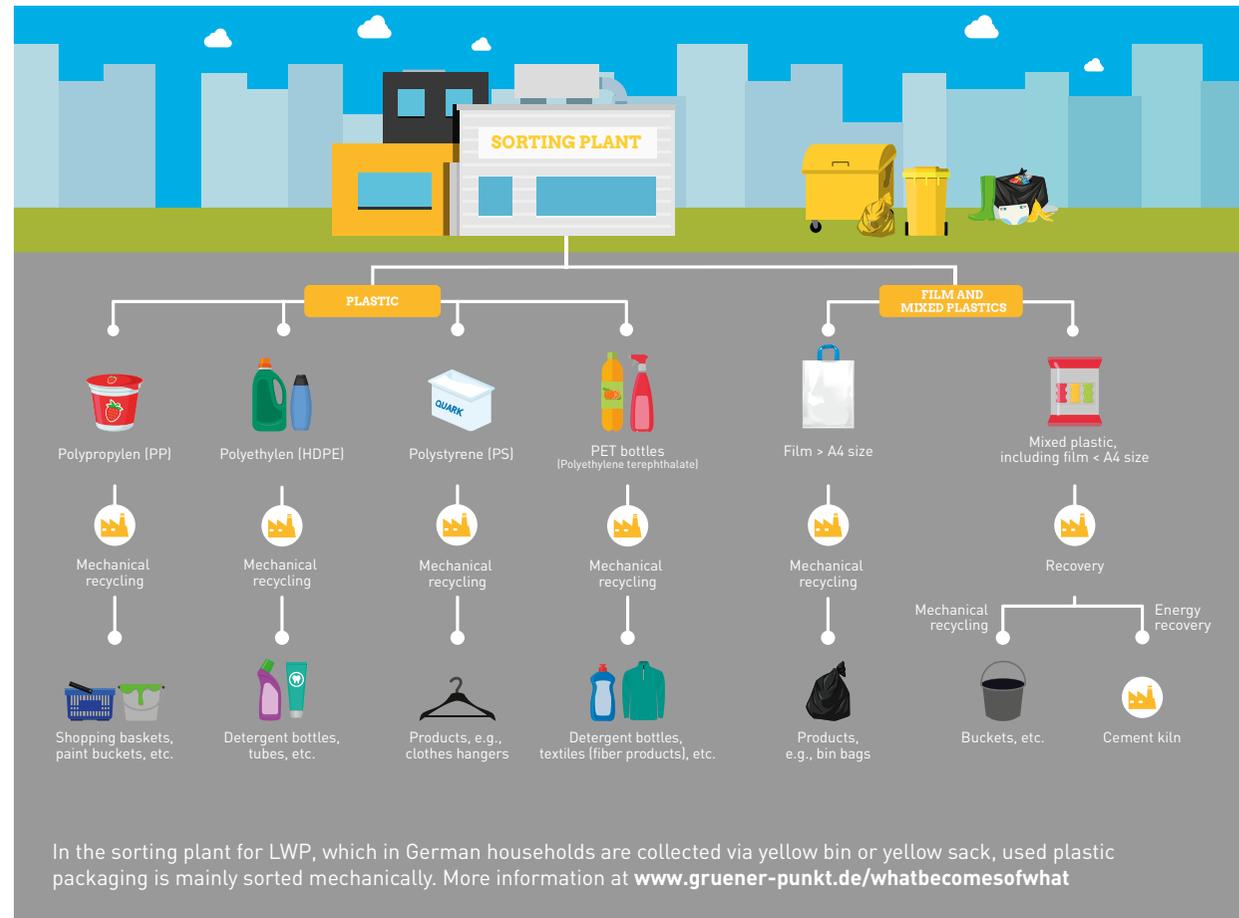
How do these processes appear in practice? First of all, lightweight packaging (LWP) collected in the designated yellow bags or containers is sorted by machine. This is the only way to recycle packaging made of the same material in the respective single flows. The packaging is not shredded; instead, it is all sorted into the proper categories. The mechanical steps include screening, magnetic separation, air separation, and eddy current separation for non-ferrous metals. These methods rely on the physical characteristics of the various materials.

» Optical sorting

In addition to these sorting steps, there are now methods for recognizing types of plastic using near-infrared spectroscopy (NIR). Packaging can only be recycled if it can be correctly identified. Example: A large label consisting of a different material than the body of the packaging can cause an error in material detection.

» Recycling processes

In the recycling process, the sorted plastic sales packaging is shredded in several stages and foreign components are removed in various washing and separation procedures. A primary process in the mechanical preparation of plastics for recycling is separation in the swim-sink tank. This separates undesirable materials of different densities. If this process doesn't work, perhaps because labels cannot be removed due to waterproof



adhesive, the product is contaminated, which has a negative effect on quality. This overview is based only on the recyclability of the materials, i.e., the preparation of plastic packaging for

mechanical recycling, because recyclability is a considerable factor in the sustainability of packaging and makes a significant contribution to climate protection.

How to use the design guide

Material profiles include the typical materials used in plastic packaging, such as LDPE (films), PP, PE, and PET (bottles). These profiles list the recyclable and non-recyclable components and materials for the respective packaging components.

The requirements and assessment catalogue of the cyclos-HTP Institute (www.cyclos-htp.de) serves as a guide as well as the minimum standard of the ZSVR. Recyclability is defined here as “the gradual suitability of packaging or a product, after it has been used, to provide an actual substitute for a new item made of identical materials.” In this definition, “actual” means that collection and recycling structures are present on an industrial scale in Germany. This eliminates purely hypothetical recyclability, i.e., a product must be truly recyclable.

In some cases, the assessment depends on the combination of materials or their concentration. Moreover, recyclability depends strongly on the various processes used to recycle the different materials. For example, EVOH/PA barrier film prevents recycling in the processing of PET bottles. In contrast, an EVOH barrier has only a limited effect on the recyclability of HDPE bottles. While labels are preferred for PET bottles – because printing directly on the bottle contaminates recycled PET material – printing directly on PP packaging is less troublesome.

» Designing the material profiles

How to read the profiles: The many different packaging solutions and material combinations are outlined in main groups based on the machine sorting specifications of Der Grüne Punkt (found in the download area at www.gruener-punkt.de/en/download). In addition, the top criteria for designing for recyclability are included in the overview. A sorting procedure for the respective packaging is imperative for its recyclability.

For example, PLA packaging is not recyclable because there is currently no sorting procedure for it.

The first column contains the recyclable parts of the respective packaging, including its various components, such as lid (cap), body, or label. Example: For a PP bottle, these would be the PP components of the overall packaging – to the extent that they can be recycled based on how they are constructed. The tables contain ratings with regard to recyclable components.

» Various levels of quality

- Fully recyclable: The optimum solution is always listed in this column, i.e. the components and materials that can be recycled completely or in part and can be separated well.

- Recyclable in certain circumstances: Such components and materials cannot be separated in the established sorting and recycling processes, but do not have a negative effect on recyclability up to a certain concentration. They cannot, however, be recycled along with other components and materials, i.e., the proportion of these components in the recycled material is not a substitute for an equivalent new item.

- Non-recyclable: These components and materials cannot be separated in the established sorting and recycling processes. They contaminate the recycled material to the point that it is unusable and reduce recyclability considerably or to zero.

The respective packaging should be evaluated individually to obtain a final and definitive assessment of recyclability. Der Grüne Punkt provides support here with the service described at www.gruener-punkt.de/en/services/design4recycling and the RecyclingCOMPASS (www.gruener-punkt.de/en/recyclingcompass), which enables the user-friendly and simple online classification of packaging according to its specification. In addition, the cyclos-HTP institute issues, by request, certificates that indicate recyclability in percent.



Sorted HDPE packaging, pressed into bales, waits to be transported to the recycling facility.



Bottles made of transparent colorless/light-blue PET

Proportion of recyclable materials: Proportion of transparent PET, including PP/PE (polyolefin) proportion in caps

	Fully recyclable	Recyclable in certain circumstances	Non-recyclable
Cap	One-piece caps made of polyolefin plastics with a density < 1 g/cm ³ (PP, HDPE, LDPE)	Magnetic components, e.g., in the trigger	Plastics with a density > 1 g/cm ³ , e.g., PET-G, PVC, POM Elastomer components with a density > 1 g/cm ³ Silicone components Non-magnetic metals
Bottle body	Clear, transparent, or a light color (e.g., light blue) No printing Can be emptied completely Plasma coating (clear)	Acetaldehyde (AA) blocker UV stabilizers TPE-PO-based	PET-G, POM components Opaque coloring or direct printing (except best-before date or batch number) Elastomer components with a density > 1 g/cm ³ Silicone components PA additives (PET-A copolymer)
Barriers	Optimum: no barrier(s) Plasma coating (clear)	Acetaldehyde (AA) blocker UV stabilizers TPE-PO-based	EVOH or PA mono-layer barrier films PA additives (PET-A copolymer) Other blended barriers
Labels (material & type of adhesion)	PP or PE labels and sleeves with a density < 1 g/cm ³ , smaller than 50% of the packaging surface	Paper labels Soluble adhesive applications (in water or alkaline at 80 °C)	Plastics with a density > 1 g/cm ³ PVC, PS, PET-G/S labels or sleeves Elastomer components with a density > 1 g/cm ³ Insoluble adhesive applications (in water or alkaline at 80 °C)
Plastic labels	No hazardous ingredients in the ink (in accordance with EuPIA)		Hazardous ingredients in the ink (components in the EuPIA exclusion list) Direct printing (except best-before date and batch number)

PET trays: Currently there is no recycling procedure for PET trays on an industrial scale.



Other bottles made of transparent colored PET

Proportion of recyclable materials: Proportion of transparent colored PET, including PP/PE (polyolefin) proportion in caps

	Fully recyclable	Recyclable in certain circumstances	Non-recyclable
Cap	One-piece caps made of polyolefin plastics with a density < 1 g/cm ³ (PP, HDPE, LDPE)	Magnetic components, e.g., in the trigger	Plastics with a density > 1 g/cm ³ , e.g., PET, PVC, POM Elastomer components with a density > 1 g/cm ³ Silicone components Non-magnetic metals
Bottle body	Transparent, colored (e.g., light green or brown) No printing Can be emptied completely Plasma coating (clear)	(AA) blocker UV stabilizers TPE-PO-based PA additives	PET-G, POM components Opaque coloring or direct printing (except best-before date or batch number) Elastomer components with a density > 1 g/cm ³ Silicone components
Barriers	Optimum: no barrier(s) Plasma coating (clear)	(AA) blocker UV stabilizers TPE-PO-based EVOH or PA mono-layer barrier films	
Labels (material & type of adhesion)	PP or PE labels and sleeves with a density < 1 g/cm ³ , smaller than 50% of the packaging surface	Paper labels Soluble adhesive applications	Plastics with a density > 1 g/cm ³ PVC, PS, PET-G/S labels or sleeves Elastomer components with a density > 1 g/cm ³ Insoluble adhesive applications (in water or alkaline at 80 °C)
Printing	No hazardous ingredients in the ink (in accordance with EuPIA)		Hazardous ingredients in the ink (components in the EuPIA exclusion list) Direct printing (except best-before date and batch number)

PET trays: Currently there is no recycling procedure for PET trays on an industrial scale.



Rigid packaging, made of PP or PE

Proportion of recyclable materials: Proportion of PP/PE (polyolefin)

	Fully recyclable	Recyclable in certain circumstances	Non-recyclable
Cap	Plastic of the same type as the bottle body (PP/PP or PE/PE)	Combination of PE and PP. For PE recycled granulate, PP reduces quality and for PP recycled granulate, PE reduces quality. Plastics with a density > 1 g/cm ³ Other thermoplastic polymers with a density < 1 g/cm ³ in a low concentration (EVA, TPE, PO-based) Aluminum cover films	Non-PO plastics of density < 1 g/cm ³ Non-separable silicone components Components of foamed non-thermoplastic elastomers
Bottle body	Mono-material Clear/colorless/light colored Can be emptied completely	Combination of PE and PP. For PE recycled granulate, PP reduces quality and for PP recycled granulate, PE reduces quality. Coloring and/or printing Very low concentration of fillers (e.g., chalk) Plastics with a density > 1 g/cm ³ Other thermoplastic polymers with a density < 1 g/cm ³ in a low concentration (EVA, TPE, PO-based)	Non-PO plastics of density < 1 g/cm ³ Non-separable silicone components Outside metallizations Components made of foamed, non-thermoplastic elastomers High proportion of plastics or fillers that significantly increases the density (> 1 g/cm ³) Coloring (dark or carbon-based) is completely lightabsorbent
Barriers	Optimum: no barrier(s) Plasma coating (clear)	EVOH barrier layer Inside metallizations	PA barriers, PVDC barriers PE-X components (for PE packaging)
Labels (material & type of adhesion)	Plastic of the same type as the bottle body Does not contain any metal	Paper labels smaller than 50% of the packaging surface Plastic of a different type with a density > 1 g/cm ³ , smaller than 50% of the packaging surface (e.g., PET) Other thermoplastic polymers with a density < 1 g/cm ³ in a low concentration (EVA, TPE) Water-soluble adhesive applications, less than 50% of packaging surface area	Different types of plastic with the same density as the main material Silicone components Components made of foamed, non-thermoplastic elastomers with a density < 1 g/cm ³ Non-water-soluble adhesive applications in combination with wet-strength paper labels
Printing	No hazardous ingredients in the ink (in accordance with EuPIA)		Hazardous ingredients in the ink (components in the EuPIA exclusion list)



Rigid packaging, made of PS

Proportion of recyclable materials: Proportion of PS

	Fully recyclable	Recyclable in certain circumstances	Non-recyclable
Cap	Plastic of the same type as the packaging body	Plastics with a density < 1 g/cm ³ and > 1.08 g/cm ³ Aluminum cover films	Foreign plastics or multi-layer packaging of density class 1.0–1.08 g/cm ³
Body	Mono-material Clear/colorless/light colored Can be emptied completely	Plastics with a density < 1 g/cm ³ and > 1.08 g/cm ³ Coloring and/or colored printing Very low concentration of fillers (e.g., chalk)	Foreign plastics or multi-layer packaging of density class 1.0–1.08 g/cm ³ Plastics or high proportions of fillers that significantly change the density (> 1 g/cm ³)
Barriers	Optimum: no barrier(s)	EVOH barrier layer	
Labels (material & type of adhesion)	Plastic of the same type as the packaging body Does not contain any metal	Soluble, affixed paper labels Paper labels smaller than 50% of the packaging surface	Foreign plastics or multi-layer packaging of density class 1.0–1.08 g/cm ³ Non-water-soluble adhesive applications in combination with wet-strength paper labels
Printing	No hazardous ingredients in the ink (in accordance with EuPIA)		Hazardous ingredients in the ink (components in the EuPIA exclusion list)



Films made of LDPE, LLDPE, HDPE

Proportion of recyclable materials: Proportion of LDPE (polyolefin)

	Fully recyclable	Recyclable in certain circumstances	Non-recyclable
Material	LDPE, LLDPE, HDPE	PP films Proportion of non-polyolefin polymers	Combination of different plastics that cannot be separated, with a density < 1 g/cm ³ High proportion of fillers that significantly change the density, e.g., of LDPE (> 1 g/cm ³) Outside metallizations
Coloring	Not printed, clear/colorless	Light colors and/or printing	Coloring (dark or carbon-based) is completely absorbent
Barriers		EVOH barrier layers, SiOx, AlOx, inside metallizations	PA barriers, PVDC barriers, other barriers such as EVOH or polymers (except SiOx, AlOx, inside metallizations) Outside metallizations
Labels (material & type of adhesion)	No labels or labels of the same material as the film Does not contain any metal	Soluble adhesive applications paper labels Proportion of non-polyolefin polymers	Non-magnetic metals (e.g., RFID tags) Non-water-soluble adhesive applications in combination with wet-strength paper labels
Printing	No hazardous ingredients in the ink (in accordance with EuPIA)		Hazardous ingredients in the ink (components in the EuPIA exclusion list)



Mixed plastics/mixed polyolefins (MPO)

Percentage of recyclable materials: PO (polyolefin) percentages

	Fully recyclable	Recyclable in certain circumstances	Non-recyclable
Material	Mono-material or combinations of HDPE and PP PP films Clear/colorless/light colored Can be emptied completely	Polyolefins that differ from the main material LDPE shares/components Coloring and/or colored printing Fillers (e.g., chalk), but only in very low concentrations PS-, PET-, PA-, PVC-, ABS-, PC- and other components Other thermoplastic polymers of density < 1 g/cm ³ in low concentration (e.g., EVA, TPE-PO-based)	Consists of various types of plastic with a density < 1 g/cm ³ Silicone components Components made of foamed, non-thermoplastic elastomers with a density < 1 g/cm ³ Foamed, non-polyolefinic components Plastics or a high proportion of fillers that significantly change the density (> 1 g/cm ³) Coloring (dark or carbon-based) is completely absorbent Outside metallizations
Barriers	Optimum: no barrier(s)	EVOH barrier layers, SiO _x , AlO _x , inside metallizations	PA barriers layers Outside metallizations
Labels (material & type of adhesion)	Plastic of the same type as the main material Does not contain any metal	Plastic of a different type with a density > 1 g/cm ³ , smaller than 50% of the packaging surface Paper labels smaller than 50% of the packaging surface LDPE shares/components PS-, PET-, PA-, PVC-, ABS-, PC- and other components Other thermoplastic polymers of density < 1 g/cm ³ in low concentration (e.g., EVA, TPE-PO-based)	Different types of plastic with the same density Silicone components Components made of foamed, non-thermoplastic elastomers with a density < 1 g/cm ³ Foamed, non-polyolefinic components Non-water-soluble adhesive applications in combination with wet-strength paper labels
Printing	No hazardous ingredients in the ink (in accordance with EuPIA)		Hazardous ingredients in the ink (components in the EuPIA exclusion list)

Best practice examples

What does plastic packaging that is easy to recycle look like? Not much different than other packaging. Because recyclability, attractiveness, and effective advertising all work well together. This is demonstrated by the images of consumer goods on this page.

A lot of packaging is already easy to recycle. Or just a small detail can be changed by using "Design4Recycling", such

as the adhesive or the label material, for example. This will not affect the function.

Our examples come from every area of the consumer goods industry – from confectionery products and frozen foods to laundry soap and cleaning agents. All of the packaging shown can be clearly and automatically sorted with machines currently in use. Components such as labels or caps can either

be separated easily or even recycled along with the items. High-quality recycled granulates are made from the plastic for use in new products such as mopping buckets, shopping baskets, or automobile parts.

More best practice examples from various areas can always be found at www.gruener-punkt.de/en.



	Pöppelmann Rundtopf PCR blue	Emsal Parkett Pflege	Bofrost Röschen-Trio	Guhl Repair & Balance	Brocker Möhren
Packaging	Plant pot	Bottle for detergents	Deep-freeze film	Bottles for hair care products	Tray and film for vegetables
Material	PP round pot	HDPE bottle, PP cap, paper labels	LDPE film	PP bottle with PP cap and PP labels or PET bottle with PP cap and PE labels	PP film and PP tray
Categorization for sorting	Clear	Clear	Clear	Clear	Clear
Recyclability	Very good due to mono-material	Very good because labels are easy to separate	Very good due to mono-material	Very good due to mono-material, labels are easy to separate	Very good due to mono-material

Assessment catalogs and guidelines

This guide is based primarily on the Requirements and Assessment Catalog of the well-known cyclos-HTP institute. Further methods and institutions have been developed in

Germany and in the European Union that assess packaging with regard to its recyclability. However, the methods of the various approaches vary and are often limited to certain ma-

terials. For orientation purposes, this table provides an overview of the most important assessment catalogs and guidelines.

	DIN EN 13430	cyclos-HTP	RecyClass	EcoPaperLoop	PTS	RECOUP	EPBP	COTREP
Type	Assessment catalog	Assessment catalog	Assessment catalog + DfR assistance	Assessment process	Assessment process	DfR guidelines	DfR guidelines	Assessment assistance
Application area	All packaging	All packaging	Plastic packaging	Packaging made of paper/cardboard	Packaging made of paper/cardboard	Plastic packaging	PET bottles	Plastic packaging
Scope of application	EU countries	Entire EU	-	Entire EU	-	International (focus on Europe, USA)	Entire EU	-
Standards applied	CR 14311; EN 13437, among others	DIN EN ISO 14021; DIN EN 13430	-	-	-	-	-	-
Definition of recyclability	Definition of recycling	Yes	-	-	-	-	-	-
Items examined/assessed	Entire packaging unit	Entire packaging unit¹	Entire plastic packaging	Entire paper/cardboard packaging	Entire paper/cardboard packaging	Individual components of plastic packaging	Individual components of plastic packaging	Individual components of plastic packaging
Assessment scale	Material recyclability with a gradual scale (0%-100%)	Recyclability with a gradual scale (0%-100%)	Recyclability with a graded scale (A to F)	Recyclability with a gradual scale (0%-100%)	Recyclability with a gradual scale (0%-100%)	Recyclability with extended traffic light rating system	Recyclability with extended traffic light rating system	Effects of specific materials on the recycling process without a scale
Point of quantification	Entrance to recycling process	Recycled granulate	Recycled granulate	Recycled granulate	Recycled granulate	-	-	-
Reference for assessment scale	New packaging	New packaging	New packaging	New packaging	New packaging	New packaging	New packaging	New packaging
Basis for assessment	Packaging components	Packaging specification and empirical analysis	Packaging specification and questionnaire	Empirical analysis	Empirical analysis	Classification based on stated material-specific indicators	Classification based on stated material-specific indicators, such as quick checks	Material specifications
References (used together)	None	Recoup, RecyClass, DIN EN 13430	EPBP	-	-	EPBP, COTREP, PRE, CITEO, among others	PRE, COTREP, among others	CITEO
Examination and assessment criteria	Based on processes from date of manufacture	Based on processes in post-use phase	See DfR guideline	Fraying and qualitative sheet-forming characteristics	Fraying and qualitative sheet-forming characteristics	Not explicitly specified; based on actual, process-specific qualitative/quantitative requirements of the particular recycling stage; sortability taken into consideration in some cases		

¹Subject to ability to be emptied completely considering waste-specific characteristics.

Source: Institut cyclos-HTP GmbH

List of abbreviations



AA blocker	Additives to inhibit the solubility of acetaldehyde from PET
ABS	Acrylonitrile butadiene styrene
AlOx	Aluminum oxide
COTREP	Comité Technique pour le Recyclage des Emballages Plastiques
D4R, DfR	Design for Recycling
EPBP	European PET Bottle Platform
EuPIA	European Printing Ink Association
EVA	Ethylene-vinyl acetate
EVOH	Ethylene vinyl alcohol
g/cm³	Grams per cubic centimeter
HDPE	High-density polyethylene
IML	In-mould labeling
LDPE	Low-density polyethylene
LLDPE	Linear low-density polyethylene
LWP	Lightweight packaging
NIR	Near-infrared spectroscopy
PA	Polyamide
PC	Polycarbonates
PE	Polyethylene
PET-A	Amorphous polyethylene terephthalate
PET-C	Semicrystalline polyethylene terephthalate
PET-G	Polyethylene terephthalate, glycol-modified
PET-S	Polyethylene terephthalate polystyrene blend
PLA	Polylactic acid
Plasma coating	Technology for applying barrier layers at the nano level
PO	Polyolefin (PP, HDPE, LDPE, LLDPE)
POM	Polyoxymethylene
PRE	Plastics Recyclers Europe
PP	Polypropylene
PS	Polystyrene
PTS	Papiertechnische Stiftung
PVC	Polyvinyl chloride
RECOUP	RECYcling Of Used Plastics limited
RFID tags	Labels with Radio Frequency IDentification technology
SiOx	Silicon oxide
TPE	Thermoplastic elastomers
UV stabilizers	Additive to increase the resistance of plastic to ultraviolet radiation

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Recycled plastic is available in more and more colors.