RecyClass

HANDBOOK ON DECORATIVE TECHNOLOGIES

APPLIED ON RIGID PLASTIC PACKAGING

STATE-OF-THE-ART DECORATIONS

VERSION 1.3

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RecyClass

CONTENT

INTRODUCTION

This document aims to map and define all existing decorative technologies applied on rigid plastic packaging made from HDPE, PP, PET & PS materials in the EU market. The following definitions are provided by RecyClass Decoration Taskforce and are complementary to the Design for Recycling Guidelines and the Design Book. This handbook targets different purposes:

- Providing an exhaustive list of the decorative technologies applied on rigid plastic packaging in the EU market;
- Harmonizing the nomenclature and definitions on decoration technologies;
- Providing clear information on the structures and application processes of decoration technologies.

As the present, the document corresponds to the current state-of-the-art, and it will be periodically updated following the latest developments on decoration technologies on rigid plastic packaging in the EU market.

Based on the exhaustive mapping, this document also enables companies to have an overview of the available decoration technologies in order to find alternatives to further improve the design-for-recycling of rigid plastic packaging. Moreover, this document aims to be used in combination with the Design for Recycling Guidelines[1] developed by RecyClass to understand the compatibility of each technology with a dedicated recycling stream.

Please note that RecyClass has performed and continues to perform several test campaigns in order to understand how different decoration features may affect the recyclability of plastic packaging. The results of these test campaigns are published in the approval section[2]

1. DECORATIVE TECHNOLOGIES MAPPING

The RecyClass Decoration Taskforce participants identified ten main categories of decorations, as listed below, that include all types of printing, labelling, metallisation, and partial metallisation technologies. Attached electronics are reported as well, even if their compatibility with mechanical recycling has not been yet demonstrated and are therefore not described in this document (*version 1.1*).

Table 1 maps the decorative technologies that are applied today on HDPE, PP, PET & PS rigid containers and summarizes their key parameters. Detailed definition and explanation of each technology can be found in section 2.

[1] *RecyClass Design for Recycling Guidelines available at:* https://recyclass.eu/recyclability/design-for-recycling-guidelines/

[2] *RecyClass Technical Reviews*

Table 1. Decorative Technologies Overview

DECORATIVE TECHNOLOGY	TECHNOLOGY SUB-CATEGORY	ADHESIVE TECHNOLOGY	TECHNOLOGY CHEMICAL NATURE	PRINTING INKS	RECYCLING BEHAVIOUR
DIRECT PRINTING	Conventional printing	No adhesive	*n.a.*	Common printing and finishing inks binders: NC, PVB, PVC, PU, Acrylates	Not separable
	Digital printing				
LASER MARKING	-	No adhesive	Laser-sensitive pigment	*n.a*	Not separable
METALLISATION	Physical vapor deposition	No adhesive	Aluminium	*Cf. direct printing*	Not separable
ELECTROPLATING	Chemical metal deposition	No adhesive	Palladium, Nickel, Copper, Gold, Bronze, Chrome	*n.a.*	Metallised parts separable by density (>1 g/cm^3)
TRANSFER TECHNOLOGIES	Cold Transfer	Water-based (dispersion)	Polyacrylates (conventional drying or UV curing) Optionally metallisation	*Cf. direct printing*	Not separable as finishing (direct printed)
	Hot Stamping	Hotmelt	Polyacrylates, Polyamides, Polyolefins, rubber, natural polymers, and more Optionally metallisation		
ADHESIVE APPLIED LABELS	Water-based adhesive (cut & stack)	Wet application before label application	Acrylic Natural polymers	*Cf. direct printing*	Separable if washable or releasable adhesive
	Hotmelt adhesive (wrap-around)	Hotmelt	Polyolefin / EVA Block-copolymer rubber		Partially separated after grinding and completely if washable or releasable adhesive

DECORATIVE TECHNOLOGY	TECHNOLOGY SUB-CATEGORY	ADHESIVE TECHNOLOGY	TECHNOLOGY CHEMICAL NATURE	PRINTING INKS	RECYCLING BEHAVIOUR
PRESSURE SENSITIVE LABELS	-	Water-based (emulsion)	Acrylic	*Cf. direct printing*	Separable if washable or releasable adhesive
		Hotmelt	Polyolefin / EVA UV-curable acrylic Non UV-curable acrylic Block-copolymer rubber		
SLEEVE TECHNOLOGIES	Heat Shrink Sleeves	No adhesive	*n.a.*	*Cf. direct printing*	Removable after grinding and wind-sifting
	Stretch Sleeves				
	Cardboard Sleeves (self-detachable)				Removable by mechanical stress (e.g., compaction)
IN-MOULD-LABELS	-	No adhesive (generally)	*n.a.*	*Cf. direct printing*	Not separable / Separable
HEAT TRANSFER LABELS	-	Water based or solvent based heat activated	Wax	*Cf. direct printing*	Not separable
DEBOSSING AND EMBOSSING	-	No adhesive	*n.a.*	*n.a*	Not separable

2. DECORATIVE TECHNOLOGIES DEFINITION

The definitions were developed by the RecyClass Decoration Taskforce, that includes companies from the entire plastic value chain and European industry associations represented by experts in field of packaging decoration. The document is recognised by the European Printing Ink Association[3] (EuPIA), the Association of the European Adhesive & Sealant Industry[4] (FEICA), and the European association for the self-adhesive label industry[5] (FINAT), who contributed toward establish a common terminology within Europe.

2.1 DIRECT PRINTING

Direct printing technology deposits ink layers on the packaging without using any substrate (e.g., label). Direct printing can be applied with various **printing processes** including silkscreen, offset, dry offset, flexography, or gravure. Each process can be characterized by the thickness of the deposited inks layer:

Table 2. Overview of Printing Processes used for Rigid Plastic Packaging

	PRINTING PROCESS	INK DEPOSIT THICKNESS*	TYPICAL APPLICATIONS
CONVENTIONAL PRINTING	Silkscreen	**5 – 280 µm**	textiles, labels
	Offset	**0.5 – 2 µm**	paper, folding carton, and as lower volume films (often UV-offset for sleeves and labels)
	Flexography	**1 – 8 µm**	all type of packaging materials
	Gravure	**1 – 20 µm**	all type of packaging materials
DIGITAL PRINTING	Inkjet	**1 – 3 µm**	all type of packaging materials
	Electrophotography	**± 10 µm**	paper mainly, and films only for specific applications (low volume)

** Coating weight (gsm) can be calculated with the density of the inks (for density of 1 g/cm^3, thickness is the same as the coating weight).*

RecyClass endorsed the **definition** of EuPIA[6] on inks:

a. Mixtures of colourants with other substances which are applied on materials to form a graphic or decorative design together with or without.

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[3] https://www.eupia.org/

[4] https://www.feica.eu/

[5] https://www.finat.com/

[6] *EuPIA definition of inks and other associated definitions can be found in the EuPIA glossary.*

b. Other coloured or uncoloured overprint varnishes/ coatings or primers which are normally applied in combination with a) in order to enable the printed design to achieve specific functions such as ink adhesion, rub resistance, gloss, slip/friction, durability etc.

However, the term "Printing inks" does not include coatings which are applied with the prime objective of enabling the material or article to achieve a technical function such as heat sealing, barrier, etc., as opposed to a graphic effect, even though they may be coloured. These "coatings" with a purely technical function should be considered separately, as they are out of the decorative technologies' scope.

Several **types of inks** have been identified as common for direct printing. Usually, inks are made of 4 different components: solvent, polymeric binder, pigments, and some additives. Several types of binders are present on the market and can be characterized by their chemical nature: NC (nitrocellulose), PVB (polyvinyl butyral), PVC (polyvinyl chloride), PU (polyurethanes), and acrylates are most commonly used binders. Other less common examples are PA (polyamides), CAP (celluloseacetopropionat), or CAB (celluloseacetobutyrat).

When considering flexible packaging, normally NC and PU binders are used.

For direct printing on cups and tubes, so called dry offset inks are used (this refers to a letterpress printing process). Inks contain a binder (not NC nor PU) plus a reactive diluent which is crosslinked after application of the ink. The binder gives the flexibility required for the application and the crosslinked reactive diluent the mechanical fastness properties like scuff-resistance. Inks for IMLs are based on similar ink systems.

Regarding printing of labels that are attached to rigid packaging (PP, HDPE, PS, PET), UV curable inks are mostly used in Europe. Next to UV curable inks, there are also Water Based inks used for printing on labels. UV curable inks consist out of 4 main components being: 1) Acrylates (e.g. polyesteracrylates), 2) pigments, 3) Photoinitiators and 4) Additives. Acrylates could be considered here as the binder.

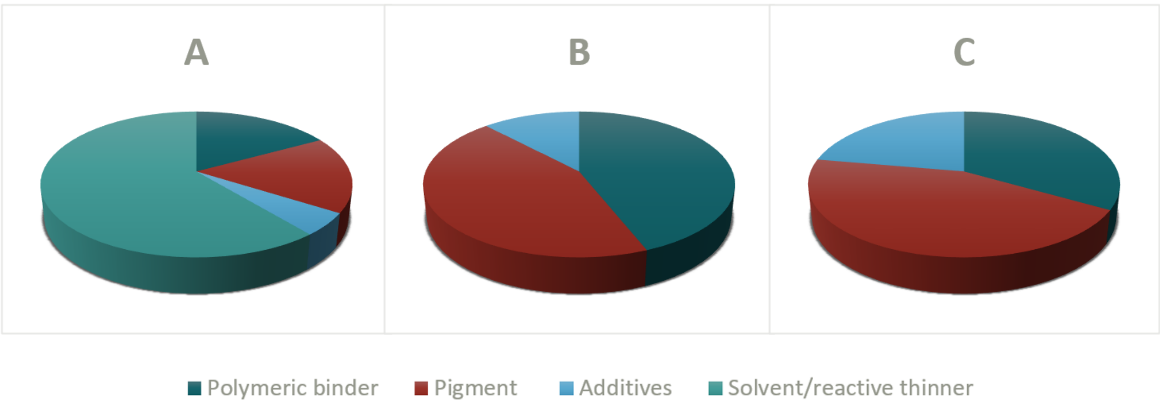

Figure 1. Composition of A) wet flexography / gravure inks, B) dried solvent or water-based inks, and C) UV- or EB-cured flexography and offset inks.

Once applied on the packaging, inks are dried by heat to remove the solvent or cured with UV (ultraviolet) or EB (electron beam) radiation. The different printing technologies use the same type of pigments. Coloured pigments are typically organic substances of different structures (Azo, Naphtol AS, Quinacridon, Phthalocyanin, etc.). For white pigments, titanium dioxide remains the main used inorganic filler, but others such as SiO_2, $CaCO_3$ or $BaSO_4$ are also used.

However, it is worth to consider separately printing and finishing:

- **Printing** is the process for ink deposition and includes all types of inks deposited by conventional and digital processes, as reported above.
- **Finishing** is related to additional coatings deposited on the printing, providing additional functions to the decoration (protection, visual aspect, etc.). Two types of finishing technologies can be identified:
    - Spraying or lacquering, that can be additional uncoloured varnish or coloured lacquer;

- Transfer technologies, such as cold foil and hot stamping (*cf*: transfer technologies section).

A sub-family of printing inks are **metallised inks**. Some types of metallic inks can provide very high reflectance properties, that differ from standard inks. Standard inks are typically formulated with metal pigments made by grinding (flakes or silver dollar type). For high end applications, inks based on PVD (physical vapor deposition) aluminium pigments can be used. It is noteworthy that standard metal pigments do not reach the high gloss level of PVD pigments.

Synonyms of metallised inks that can be found on the market are: VMF or VMP based inks (vacuum metallised flakes or pigments). Moreover, **digital printing technologies** (e.g., conductive inks) applied with conventional printing processes are also under development and should be investigated in the future.

2.2 LASER MARKING

As an alternative to direct printing, some companies have developed a laser marking technology where no inks are used. A masterbatch is added to the polymer with a laser-sensitive pigment, in order to be later on treated with a laser. The dosage of the masterbatch is about 2 %. Laser pigments enable the reaction with the laser either by absorption or react themselves as colour former.

2.3 METALLISATION

Metallisation is deposited via **Physical Vapor Deposition** (PVD, Vacuum metallisation or PVD substrates). Aluminium metallisation is deposited on the substrate, that can be either the container or a label, representing a thin aluminium layer (about 100 nm).

For most of the label industry, metallisation is incorporated by the manufacturer of the substrate prior to printing. A few printers/converters apply metallisation in-house. Metallisation can be applied on paper labels as well. Printing metallised substrates often requires the use of a primer, prior to applying white and/or colours inks.

2.4 ELECTROPLATING

Another process to deposit a metal coating on a rigid packaging is **electroplating** (or galvanization), that consists of the metallisation of different metals by electrolytic deposition (aluminium, chrome, bronze) representing a thicker layer (0.1 to 1 mm). In detail, electroplating is the deposition of metal ions onto plastic parts (containers, caps, other rigid attachments) via an electrochemical process. The process consists of two phases:

Figure 2. Electroplated plastic

- **Chemical phase**: The substrate surface must be conductive, and plastic is not. The chemical phase aims at making the plastic surface conductive. Surface roughness is created to facilitate metal deposition. Palladium is embedded into the porosities, which metal will catalyse the deposition of chemical nickel, making the surface conductive.
- **Electrodeposition phase**: deposition of successive metal layers on the substrate. Copper is plated as malleable metal (accepts the curbs of the substrate) and covered with nickel to protect it from oxidation. The final deposit can be palladium, gold, bronze, nickel, or chrome depending on the colour required.

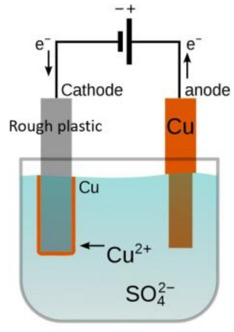

Figure 3. Electroplating process

Types of substrates commonly used are ABS, ABS-PC and PP, and layers distribution is the following:

- 1st layer: Palladium
- 2nd layer: Nickel – 0.1 µm
- 3rd layer: Copper – 10 to 20 µm
- 4th layer: Nickel – 5 to 15 µm
- 5th layer: Palladium – 0.03 µm OR Gold – 0.05 µm OR Bronze OR Nickel OR Chrome – all 0.1 to 0.2 µm

Electroplating can only be applied on filled plastic parts to allow for metal deposit. The density of those parts may thus increase, leading to densities greater than 1 g/cm^3 for the PP parts and therefore, modifying their floating behaviour.

2.5 TRANSFER DECORATIONS

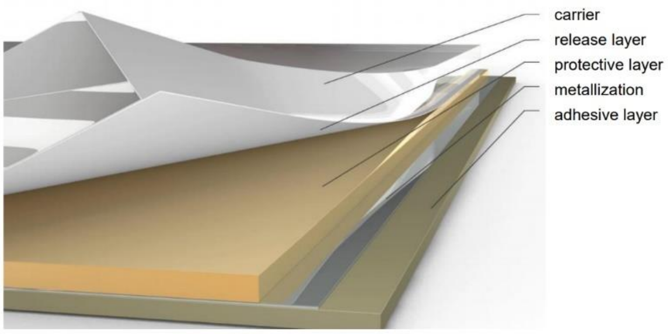

Figure 4. Common structure for transfer decoration

There are two main technologies for transfer decoration. Both are characterized by a multilayer structure that includes metallisation as reported in Figure 4. Metallisation is optional and made by physical vapor deposition (~ 10 nm aluminium and representing about 1 % of total decoration weight).

Apart from the carrier and release layer, all layers will be transferred to the packaging. As reported above, transfer decorations can be characterized as finishing technologies.

2.5.1 HOT STAMPING

Hot stamping is mostly used offline when embellishment is required on a pre-printed substrate. Three processes exist to apply hot stamping as shown in Figure 5: Peripheral stamping (the substrate rotates while decorated), Vertical Stamping (process illustrated on the left), and Roll-on (process illustrated on the right).

Figure 5. Vertical stamping process (left) and Roll-on stamping process (right).

The processes require no prior nor subsequent treatment processes such as priming or curing. The transfer process as such is a physical operation. The optically active layers of the hot stamping product are transferred to the print substrate by means of a heated stamping die and mechanical pressure. During the transfer process, the raised surfaces of the die come into contact with the hot stamping product. In the areas of contact, layers are released from the carrier foil and simultaneously bonded to the print substrate because of the heat of the die and defined contact pressure and time (adhesive being an integral component of the hot stamping foil).

Figure 6. Example of packaging after hot stamping

The **types of inks** used for the printing are the same as for conventional direct printing (*cf*: Direct printing section). The **coating weight** depends on the process and is related to the thickness of transfer finish, around 2,5 g/m² (including protective, metallization and adhesive layer).

2.5.2 COLD TRANSFER

Often described as an evolution of hot stamping, cold transfer is a method of applying metallic layers onto a substrate utilizing an adhesive rather than the die as in hot stamping. Cold transfer can be done in two ways and they differ based on the application methods, the transfer technique employed, and the components used (i.e., substrate, adhesive and product grades). Synonym of this technology is cold foiling, while additional proprietary processes can be used to name cold transfer technologies.

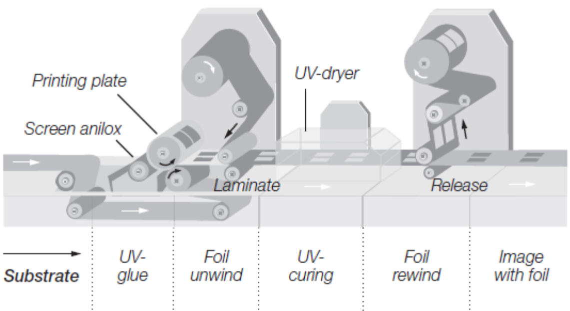

Figure 7. Representation of Cold transfer process

Two **processes** are used to obtain the printing of the cold transfer:

- Narrow-web flexographic (or letterpress or offset printing): mainly used for self-adhesive labels made of plastic, generally PE or PP. Paper labels, tube laminates, IML labels and folding boxes are more and more often being finished by means of narrow-web printing as well.
- Sheet-fed offset printing: predominantly used to finish commercial print jobs, magazines, packaging, and wet-adhesive labels.

Additional proprietary processes exist as well to decorate extruded tubes with a metallised transfer product, that can differ from narrow-web and sheet fed decoration.

Conventional and digital printing processes can both be used to apply metallised layers via print foils for cold transfer. As for hot stamping technology, the **types of inks** used for printing are the same as for conventional direct printing (*cf*: Direct printing section). No solvent is used ("dried inks"). The **coating weight** depends on the process and is related to the thickness of transfer finish, around 2 g/m² (including protective, metallization and adhesive layer).

Figure 8. Example of tubes with Cold transfer decoration

2.5.3 TRANSFER DECORATION OVERVIEW

The following table summarizes where the transfer decorations can be applied:

Table 3. Application domains of transfer decorations

DECORATION / PLASTIC SUBTRATES	DISH, CAP, MASCARA	LABELS	SLEEVES	TUBES
HOT STAMPING	✓	✓	✓	✓
COLD TRANSFER		✓	✓	✓

2.6 ADHESIVE APPLIED LABELS

There are two main technologies for adhesive applied labels. Both are characterized in that adhesive is applied to the label or container immediately prior to the label application during the labelling operations.

Figure 9. Example of adhesive applied labels

2.6.1 WATER-BASED ADHESIVE / WET LABELLING ADHESIVE

Wet labelling (or cut & stack labelling) is used for the attachment of a pre-cut label. The back of the label is coated during application with a water-based adhesive (natural or synthetic polymer). The adhesive typically covers the entire surface.

The labelstock is paper, with a thickness between 80-100 µm. Labels are supplied in pre-cut singles. Paper labelstock is porous enough to typically allow for wash-off at relatively mild[7] conditions.

The adhesive is either acrylic-based or made from natural polymers such as starch and casein.

Figure 10. Example of (top) wet labelling adhesives, (bottom) hotmelt adhesive uses

2.6.2 HOTMELT ADHESIVE

Hotmelt labelling (or wrap-around labelling) is used for labels that wrap around the full circumference of the packaging. This type of label is fixed by applying hotmelt adhesive, typically at the leading and trailing edges, on the labelling line.

The labelstock typically is white-opaque and transparent OPP, or to a minor extent PET and PE, with a thickness of the substrates between 30-50 µm. Labels are supplied as rolls. The nature of the adhesive is typically polyolefin / EVA or block-copolymer rubber hotmelt.

Wrap-around labels can also be paper based.

Adhesive applied labels are printed by gravure, flexography (UV and solvent based), offset lithography and digitally.

Fibre-based decorations can also be applied on rigid containers using hotmelt adhesive. The manufacturing process consists of the production of the fibre-based wrap with offset printing and a wrapping step where the label is wrapped around a thermoformed or blow-moulded container.

Figure 11. Example of a paper banderol decoration on plastic packaging

The **fibre-based materials** are divided into two categories based on their weight and thickness:

- Paper materials with a basis weight below 225 gsm or a thickness less than 0.1 mm. Thin paper (below 110 gsm) can typically be used in banderol applications.
- Cardboard-based materials with a higher basis weight – up to 250 gsm for recycled paper cardboard – and thicker than paper materials.

[7] *European standard recycling processes for HDPE & PP rigid packaging use cold washing conditions (20-40°C) without caustic soda.*

Hotmelt adhesive is applied either on whole surface of the fibre-based materials or applied in the thin overlap area of the cardboard wrap. In the latter, fixing cup and cardboard wrap is partly done with adhesive, applying a few hotmelt dots or an entire hotmelt line.

The **printing inks** are vegetable oil based or water based. Mostly printing on outer face only, in exception also partly in inner face with single colour.

2.7 PRESSURE SENSITIVE LABELS / SELF-ADHESIVE LABELS

In their delivery form, Pressure Sensitive Labels (PSLs) have a three-layer structure:

- **Facestock**: can be either film or paper. Films are typically clear, white, or metallised. Papers are typically white or metallised.
- **Pressure sensitive adhesive**
- **Release liner**: is a silicone coated polyester (PET) film, glassine paper or to a smaller extent BOPP film. The liner is always separated during production and should not be considered in the PSL structure applied on packs, as it will not reach the common packaging waste streams. Dedicated liner recycling streams do readily exist.

Figure 12. Example of Pressure Sensitive Label

It is worthwhile to also include "linerless" labels, that have the following construction: Silicone release layer – Print – Facestock – Pressure sensitive adhesive, and no liner used.

The following representation provides a schematic of PSL production:

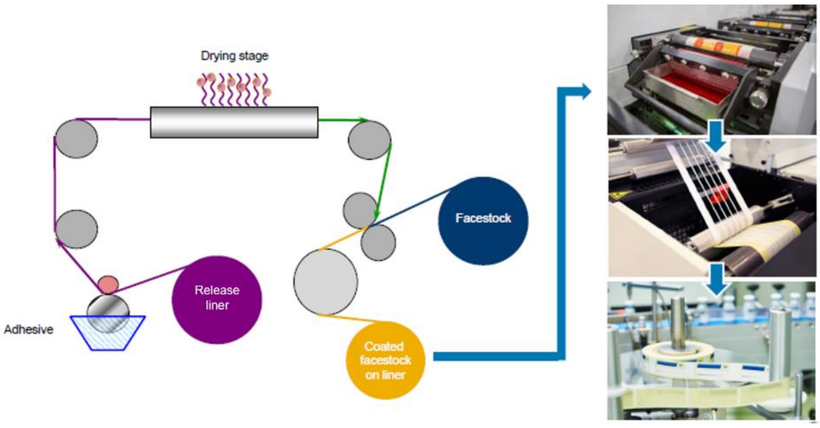

Figure 13. Schematic representation of PSL production

PSLs can be printed in many different technologies including UV, solvent, and water-based inks via gravure, flexography screen, offset or digital print processes, and the print may be protected by a varnish layer or a filmic overlaminate.

Functional requirements will determine adhesive technology. The adhesives used for PSL production can be classified in four chemistries:

- Acrylic dispersion or emulsions
- Polyolefin / EVA hotmelt
- UV-curable acrylic pressure sensitive hotmelt
- Non-UV-curable acrylic pressure sensitive hotmelt
- Block-copolymer rubber PSA hotmelt

Solvent based acrylics are relatively uncommon today for label applications as they are most commonly used in high end pressure sensitive applications such as pharmaceutical, durables, outdoor, construction and roadworks.

The coating weight of pressure sensitive adhesives could range from 10 – 25 gsm, with 12 – 17 gsm being the most common.

PSLs can be designed to be permanent, removable, or washable. The behaviour of the label is strongly linked to the type of substrate (e.g., type of container) on which the label is applied. The washability of the label can be easily assessed according to RecyClass and EPBP Washing Quick Test Procedures[8].

Figure 14. Example of applied PSL

2.8 ADHESIVES AND LABELLING OVERVIEW AND TERMINOLOGY

The following table summarizes the correlation between adhesive function and chemistry[9].

Table 4. Type of adhesives depending on their chemistry

CHEMISTRY / FUNCTION	WET LABELLING	HOTMELT LABELLING	PRESSURE SENSITIVE LABELS
ACRYLIC RESIN DISPERSION / EMULSION	✓		✓
NATURAL POLYMER-BASED ADHESIVES	✓		
HOTMELT ADHESIVES: • POLYOLEFIN / EVA		✓	✓
• UV-CURABLE ACRYLIC			✓
• NON-UV CURABLE ACRYLIC			✓
• BLOCK-COPOLYMER RUBBER		✓	✓

Pressure sensitive wordings are defined by FINAT as reported below:

- **Pressure sensitive**: American term for self-adhesive (and materials).
- **Pressure sensitive label stock**: The combination of face material, pressure-sensitive adhesive, and release liner from which pressure sensitive (self-adhesive) labels are manufactured.
- **Pressure sensitive laminate**: The combination of face material, pressure sensitive adhesive, and release liner used for manufacturing self-adhesive labels.

[8] RecyClass Testing Protocols

[9] *Source: FEICA Terminology and definitions to be used in the context of plastic packaging recycling. More information on* FEICA website.

- **Pressure Sensitive Adhesive** (PSA): An adhesive which remains 'tacky' when dry and which is used in the manufacture of self-adhesive labels.

Additional definitions provided by FEICA are useful to define the adhesive behaviour during the recycling process and applies for all adhesive applied labels' categories listed above:

- **Water-soluble / alkali-soluble adhesive application**: Any applied adhesive capable of dissolving in water or alkali in the recycling process. The dissolved adhesive is transferred into the process water and remains in solution until the washing liquid undergoes a recovery or cleaning step.
- **Releasable adhesive application**: Any applied adhesive capable of releasing on at least one side of its bond under the specified conditions in the recycling process. After releasing, the adhesive remains on one or on both substrates. The process water does not accumulate adhesives (it is not recommended to recycle the washing solution).

2.9 SLEEVE TECHNOLOGIES

2.9.1 HEAT SHRINK SLEEVE

Shrink sleeve (or shrink sleeve labels) are wrap around sleeves that utilize heat in the application process to shrink the sleeve to the shape of the container, instead of coating on the surface with an adhesive. Adhesive is not required in sleeving operations. Two types of shrink sleeve exist depending on the process direction: transverse direction (TD) & machine direction (MD).

TD shrink sleeve is processed under heat in the transversal direction only to accommodate contoured containers. The sleeve is supplied in tube form and applied over a container and then shrunk using radiant heat, hot air or steam. The sleeves are held in place by tension and intimate contact with the container only.

Figure 15. Example of heat shrink sleeve on bottle

MD sleeves shrink in the machine direction and not in the transverse direction. In this case the tube is formed in the labelling equipment at the point of application and then applied over the container and shrunk similarly to TD sleeves. Today, a vertical dual perforation line can be incorporated for the purpose of removing the sleeve from the container prior to disposal by the consumer.

Most commonly used **shrink sleeve materials** in Europe are PET-G and OPS films typically in the range of 30-50 µm in thickness. PVC shrink films have almost completely been replaced in EU markets because of environmental perceptions and concerns. Other materials such as PLA, foamed PS and foam/film laminates are used in limited quantities and can be considered niche products. Innovation materials include polyolefin-based (mix PE/PP) TD shrink materials that have density below 1g/cm^3.

Like pressure-sensitive labels, TD shrink sleeve can be **printed** by gravure, flexography (UV and solvent based), offset lithography and digitally. Unlike traditional labels, the ink is printed on the inside of the sleeve instead of on top of the label material (reverse printing). This allows the film to naturally protect the ink as it adheres to the container.

2.9.2 STRETCH SLEEVE

The stretch sleeve (or stretch sleeve labels) is supplied in tube and applied by stretching over a container. Tension is released when the label is in the correct location and the labels are held in place through intimate contact with the container only. No adhesives are used in this type of sleeving operation. Stretch sleeves are printed in flexography.

Certain types of stretch sleeve are made of modified polyethylene (LDPE) film, typically 50 µm in thickness. Stretch sleeve films may also contain linear low-density polyethylene (LLDPE). It is useful to note that stretch sleeves have an "intended breaking point" that under pressure (e.g., during collection/transfer car/sorting) enables sleeve to separate from the body.

2.9.3 CARDBOARD SLEEVE

Less commonly used than plastic sleeves, cardboard sleeves can also be wrapped around plastic containers – mainly cups – to decorate. The manufacturing process consists of the production of the cardboard wrap with offset printing and a wrapping step where the cardboard is wrapped around a thermoformed container. As for the other sleeves categories, no adhesives are used in this type of sleeving operation.

Figure 16. Example of cardboard sleeve on plastic cups

The **printing inks** are vegetable oil based or water based. Printing is done mostly on outer face only, and in exception partly in inner face with single colour.

Two types of **cardboard materials** are used: either virgin paper 190-200 g/m² or recycled paper 230-250 g/m².

Innovative cardboard sleeves are designed to be self-detachable when subject to mechanical stress. This results in the separation of the plastic cup and the cardboard sleeve during waste collection and compaction, allowing higher recycling rates and practically no contamination of the plastic stream. A sorting test[10] is mandatory to assess the behaviour of this kind of decorative technology.

2.10 IN-MOULD-LABELS

In-mould labelling is the use of paper or plastic labels during the manufacturing of rigid PP and HDPE packaging by blow moulding, injection moulding, or thermoforming processes. The label serves as an integral part of the final product, which is then delivered as a pre-decorated item.

Figure 17. Example of In-Mould Label on packaging

IML is a fully automated process in which a pre-printed paper or film is inserted into a mould before the container is created. As the container is being formed, the container resin fuses into the label, thus wedging it on the sidewall of the container structure. Because IML is firmly attached to the container, it will enter the recycling process with the container.

Printing methods of IML are (UV-) Offset, (UV-) Flexography, Digital Printing, Rotogravure, UV Rotary Letterpress.

The vast majority of IML labels have no adhesive on the backside as the container melts into the label. In case paper IML labels for blow moulding are used, the paper label can have an adhesive on the backside.

Polypropylene is commonly used as **label material**, with a thickness of 40-110 µm resulting in a mono-material packaging. PE and paper are less used materials for IML decoration.

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[10] *Sorting behaviour of plastic packaging can be assessed following the RecyClass Sorting Evaluation Protocol (https://recyclass.eu/recyclability/test-methods/)*

New IML systems have proved to be releasable from the plastic container. These IML systems are removed during the pre-treatment steps of the recycling process, specially during the grinding, washing and air elutriation steps. These developments are key when ensuring the value and maintaining the quality of transparent and white recyclates.

2.11 HEAT TRANSFER LABELS

A heat transfer label is a specific type of decoration, which is transferred from a carrier (transfer paper or foil) onto an object using heat (and pressure). The carrier holds a release layer specific to the print process and the type of product to be decorated. As there is no face stock material present, the result is a "no-label" look with ink + wax construction applied at a total thickness of about 10 µm. Gravure, flexographic, and digital print processes are used to produce heat transfer labels.

2.12 DEBOSSING & EMBOSSING

Debossing consists of having a design that is sunk into the surface of the packaging. The design is created by having a production tool designed specifically to incorporate these motifs on the plastic packaging when moulding it via injection moulding, blow moulding, etc.

Regarding embossing, the concept is the same. The design is created via the production tool. It can be understood as the opposite of debossing since the designs here are not sunk but raised from the packaging surface. Therefore, the design stands out from the surface of the component.

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DOCUMENT VERSION HISTORY

VERSION	PUBLICATION DATE	REVISION NOTES
1.0	January 2022	Terminology of Decorative Technologies applied on LDPE & PP Flexible Packaging release.
1.1	May 2022	Name changed to Handbook on Decorative Technologies applied on HDPE & PP Rigid Packaging. Addition of information for all decorations.
1.2	December 2022	Wording corrections.
1.3	December 2023	- Addition of laser marking. - Addition of removable IMLs. - Addition of debossing and embossing. - Clarification of inks used on rigid packaging. - Alignment of units format with BIPM guidelines *https://www.bipm.org/en/publications/si-brochure*. - Paragraph referring to RecyClass technical reviews. - General changes regarding format.

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