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CEPI EUROKRAFT
European Producers of Sack Kraft Paper and Kraft Paper

PAPER SACKS – DESIGN FOR RECYCLABILITY GUIDELINES

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- **4evergreen** – a cross-industry alliance of over 100 members representing the entire life cycle of fibre-based packaging – from forests to designers, producers, brand owners and recyclers. Together, they share the expertise to develop tools and guidelines for an even more sustainable sector. The goal of the 4evergreen alliance is to reach a 90% recycling rate for fibre-based packaging by 2030.
- **Alier** – a paper manufacturer making use of recycled fibres (including paper sacks) to produce high-quality packaging materials such as 100% recycled content kraft paper.
- **Cartiere Saci** – a leader in the production of packaging papers from 100% recycled raw material (including paper sacks).
- **Cepi** – the European association representing the paper industry.
- **Cepi Containerboard** – the European industry association representing producers of corrugated case materials, including those producing materials from recovered fibre in standard recycling mills.

FOREWORD

CEPI Eurokraft and EUROSAC and their members – the producers of sack kraft paper and those businesses converting sack kraft paper into paper sacks – are committed to contributing to the transition to a bio-based, low-carbon and circular economy. To support this objective, we have adopted an ambitious roadmap to help us deliver high-performance and sustainable packaging for bulk products.

The roadmap identifies areas for action at an industry level. One action area within the roadmap is to ensure that post-use paper sacks achieve a high level of recycling. To achieve this, three pre-existing key elements need to be available:

- There must be collection/sorting systems in place that cover significant and relevant geographical areas.
- There must be an existing recycling system in place that recycles the packaging.
- There must be a harmonised, EU-wide system for engaging consumers with sorting instructions and homogeneous labelling to help with the correct delivery of waste into the appropriate collection streams.

In addition to the presence of these system requirements, producers must strive to ensure that:

- The individual package is designed to be compatible with these systems and processes.
- Materials are chosen considering the wider sustainability implications of the package across the life cycle.

Within Europe, paper sacks will mostly be collected as part of a mixed stream of paper packaging for recycling. They will then be recycled within standard recycling mills and special recycling mills, along with other papers, to produce recovered paper grades such as corrugated base papers.

Of course, when considering recyclability, the effect of the contents of the package should also be considered. The presence of product residues can inhibit recycling or potentially significantly reduce the quality of the recovered pulp that is produced. However, these guidelines are aimed at producers and specifiers of paper sacks, and therefore concentrate on the aspects of paper sack design which influence the potential recyclability of the sack at end-of-life, regardless of what the sack is used for and how well the end-user empties and de-dusts the sack. It is important that paper sacks placed on the market today are designed to be compatible with collection and recycling of the mixed

packaging paper grades. Through these design for recyclability guidelines, it is intended to provide sack kraft paper producers, paper sack converters and paper sack fillers with insights into the material and design elements that influence the recyclability of paper sacks. Armed with this information, the value chain can make informed design decisions in order to maximise the recyclability of the paper sacks they place on the market.

Technology and policy relating to collection, sorting and recycling is fast moving.

Subsequently, these guidelines will be reviewed regularly and updated as necessary to reflect the dynamic situation. Users of the guidelines are encouraged to check that they are accessing the most recent version.

CEPI Eurokraft (Stockholm) and EUROSAC (Paris)

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GLOSSARY

Adhesive lamination Adhesive lamination is the bonding of one or more layers of material through the use of adhesives. The adhesive is generally a polymer that is applied in a single coat or in a spray pattern that ensures good bonding.

Bio-based Materials or fuels derived from biomass (living matter such as trees and plants, chitosan from shellfish, etc).

Biodegradable A substance or object capable of being decomposed by bacteria or other living organisms.

Collection Separate collection of paper and paper products from industrial and commercial outlets, from households and offices for recovery. Collection includes transport to the sorting or recycling plant/paper mill, and is calculated as the utilisation plus exports minus imports of paper for recycling. The difference between the collection and utilisation of paper for recycling can be explained by trade, stock variations and some volumes destined for other material recycling options.

Converting Manufacture of products by processes or operations applied after the normal paper or board manufacturing process. The operation of treating, modifying or otherwise manipulating the finished paper and paperboard so that it can be made into end-user products, such as special coating, waxing, printing and gumming, as well as envelope, bag and container manufacturing.

Deinking Deinking (also de-inking) is any process, in addition to slushing and incidental washing, intended to remove most of the ink particles from pulp made from recovered printed paper or board (ISO 4046-2, 2016).

Dispersion coating In dispersion coating, the coating polymer is dispersed in water often using a surfactant. Once the coating is applied, the liquid medium is evaporated leaving behind a coating film.

EN 643 – European List of Standard Grades of Paper and Board for Recycling The EN 643 list gives a general description of the standard paper and board grades by defining what they do and do not contain.

Extrusion coating and extrusion lamination A process of placing a layer of polymer onto the surface of a substrate by extruding a thin film of molten resin and pressing it onto or into the substrates, or both, without the use of adhesives.

Fibre-based packaging material The sum of papermaking fibres, fillers added in the wet-end, pigments used in printability coating, binders used as a minor fraction in pigment printability coating, starch and other dry strength agents, and other functional and process chemicals used in the wet-end of paper machine, printing inks, overprint varnish, as well as adhesive used to bind two layers of paper (or paper and plastic film) together, barrier layers, and any additional/auxiliary items (closure, tape, label).

Fossil-based Materials or fuels derived from fossil resources such as oil or natural gas.

Mechanical pulping Wood pulp, including reject pulp, obtained by grinding or milling into relatively short fibres, coniferous or non-coniferous rounds, quarters, billets, etc. or through refining coniferous or non-coniferous chips. Called stone groundwood pulp and refiner groundwood, it can include pre-treatment with chemicals (i.e. chemi-mechanical pulp), and it can be bleached or unbleached. This pulp is used mainly in newsprint and wood-containing papers, like LWC (lightweight coated) and SC papers.

Mill The building or buildings and area where the pulp and papermaking operations are carried out. Sometimes called a plant when referring to one area of the whole operation. It can also refer to rotating steel rolls used in mixing materials.

Near-infrared (NIR) sorting Near-infrared sorting technologies measure the reflected light of an object in the range of 760 and 2,500 nm. NIR is used in the sorting process to separate packaging types from each other based on reflected surface material.

Paper Paper consists mainly of natural fibres and can possibly contain other ingredients such as fillers, starch, coating colour including binder, as well as additives typically used in the paper industry such as wet-strength agents, sizing agents and bound water.

Paper for Recycling (PfR) Natural fibre-based paper and board suitable for recycling and coming in any shape. Products made predominately from paper and board, which may include other constituents that cannot be removed by dry sorting, such as coatings and laminates, spiral bindings, etc.

Recycling The mechanical reprocessing of used materials in a production process into new materials.

Pulp Fibrous material in papermaking produced in a pulp mill, either mechanically or chemically from fibrous cellulose raw material (wood most commonly).

Pulping The act of processing wood (or other plant-based sources) to obtain the primary raw material for making paper, usually cellulose fibre. Wood is the most widely used source of fibre for the papermaking process. The fibres are separated from one another into a mass of individual fibres. The separation can be undertaken by a mechanical process, where the fibres are teased apart, or by chemical means, where the lignin binding the fibres together is dissolved away by cooking the woodchips in suitable chemicals. After separation, the fibres are washed and screened to remove any remaining fibre bundles.

Standard recycling mill Such mills produce high-quality end products with a classic low-consistency pulper (5% fibre concentration). Often such processes operate deflakers to separate fibre bundles into individual fibres, as well as coarse- and fine-screening cleaners. The aim is to separate the fibre from the other material. The final result is fibrous material suspended in water ready for papermaking (i.e. recycled pulp). This equipment and process can handle paper-based packaging with basic mechanical transformation. It can also handle paper containing inks, water-soluble chemicals and small amounts of converting products, such as staples, adhesive tape or glues based on starch or other water-soluble adhesives.

Special recycling mill These mills treat a mix of grades. Each recycling mill determines the optimal mix and adds one or more pieces of dedicated equipment or processes, such as a horizontal high-density drum pulper, a separate batch pulper with longer pulping time, deinking, fine cleaners, hot dispersion, special process and wastewater systems. These special recycling mills can treat paper-based packaging that has been layered with non-water-soluble products, such as wax, plastic film or other layers including aluminium, polyester and polyethylene, entering the recycling process in homogeneous lots. In order to optimise the recycling process, paper composite packaging, which cannot be handled in standard processes, should be delivered to special recycling mills. As in standard mills, the result of the process is also very high-quality fibrous material suspended in water ready for papermaking.

LIST OF ABBREVIATIONS

Abbreviation	Meaning
ABS	Acrylonitrile butadiene styrene
COD	Chemical oxygen demand
EEA	Ethylene and acrylic acid
EuPIA	European Printing Ink Association
EVA	Ethylene vinyl acetate
EVOH	Ethylene vinyl alcohol
MOAH	Mineral oil aromatic hydrocarbons
MOSH	Mineral oil saturated hydrocarbons
NIR	Near-infrared
PAE	Polyamide-epichlorohydrin
PE	Polyethylene
PLA	Polylactic acid
PVA	Polyvinyl acetate
PVDC	Polyvinylidene chloride
SB	Solvent-based

ABOUT PAPER SACKS

Paper sacks and paper bags are a bulk packaging solution used for a variety of applications including cement and building materials, food ingredients (such as flour and milk powder), pet food and animal feed, seeds, and chemicals and fertilisers. The terms paper sacks and paper bags are often used interchangeably, but a distinction can be made between the two:

- **Paper sacks** – this term can be more accurately applied to larger flexible containers made from paper for shipping industrial products between businesses, generally more than 10 kg net content. In Europe, paper sacks may contain up to 25 kg of product, so strength is a key feature. Such paper shipping sacks are more likely to arise as waste in commercial and industrial waste streams.

- **Paper bags** – this term can be more accurately applied to smaller consumer-sized packages, generally less than 10 kg net content. Such paper bags are more likely to arise as waste in household waste streams.

Both solutions are manufactured from sack kraft paper. These guidelines particularly focus on paper sacks, although many of the recommendations will also be applicable to paper bags, and indeed other packaging solutions such as paper carrier bags. Sack kraft paper is manufactured from chemical pulp produced predominantly by the kraft sulphate process. The paper sheet owes its renowned strength to the long virgin fibres which are obtained from slow-growing softwood coniferous species. Sack kraft paper is characterised by its porosity, high elasticity and high tear resistance. These properties are harnessed in a range of kraft paper sack formats which are used to package heavy powdered industrial produce which needs to be de-aerated during high-speed filling, such as construction materials (e.g. cement) and foodstuff such as flour.

Increasingly, sack kraft is being used in a wide variety of consumer sacks for pet food, animal feed and food for human consumption, chemicals, garden waste collection as well as e-commerce applications.

Sack kraft paper is available in brown or white and is approved for use in contact with food. The sack kraft paper can include wet-strength agents when resistance to moist produce is required.

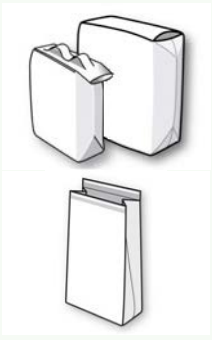
The fibre used to produce sack kraft paper is predominantly FSC, PEFC or SFI Chain of Custody certified.

Depending on the application, a paper sack may consist of one or more plies of paper and may also incorporate other materials such as polymers (either as coatings or free film layers) in order to enhance the packaging properties such as oxygen barriers, water vapour barriers, moisture resistance, grease resistance, etc. The correct combination of materials ensures product protection safety, whilst preventing waste by protecting the contents from deterioration. Whatever the product, only the necessary quantities of each material are used in order to achieve product safety and package functionality.

A range of industrial and consumer kraft paper sacks are available.

Most paper sacks are consumed in businesses. Such industrial sacks tend to be either valve or open-mouth sacks:

- **Valve sacks** (so called because they have a valve or opening where they are filled) are used for the automated filling of powdered and granular products such as construction materials and foodstuff. They are shaped to allow the sack to stand during filling and to optimise palletisation.
- **Open-mouth sacks** are used for automated and manual filling of food products such as sugar, flour and animal feeds.



Both sack constructions are available mainly as 10–25 kg capacity and provide a tear-resistant printable pack which is designed to be palletised for transport and distribution with minimal supply chain damage.

Some paper sacks are targeted at consumers. These sacks are used with a wide variety of produce including pet food, food for human consumption, animal feed and construction materials. There is growing interest in this packaging format from brands and retailers to substitute plastic primary packaging. This has necessitated the development of functional barrier coatings which are compatible with the paper recycling processes at standard recycling paper mills.

Paper sack constructions vary hugely, but five basic constructions are representative of >80% of the paper sacks on the market:

1. Printed valve sack made of two paper plies (layers) (typically white kraft 70 gsm + brown kraft 70 gsm) with internal paper valve – representative of 25 kg flour or animal feed sack.
2. Printed valve sack made of three plies (typically 70 gsm white kraft + brown kraft 70 gsm with a middle layer of 10 micron HDPE-free film) with traditional reinforced valve – representative of 25 kg cement or other building materials.
3. Printed open-mouth sack made of three plies (typically white kraft 70 gsm + brown kraft 80 gsm + 15 micron LDPE coated brown kraft 70 gsm) – representative of seeds or animal feed sack.
4. Printed open-mouth sack made with three plies (typically 90 gsm brown kraft paper + 90gms brown kraft paper + 60 microns LDPE tube) – representative of paper sack for powdered milk.
5. Open-mouth sack made of three plies (typically white greaseproof clay coated paper 80gms fully printed with non-slip glossy varnish + brown kraft paper 70gsm + 23 microns LDPE coated 70 gsm brown kraft paper) – representative of a pet-food sack.

For all sack and bag types and constructions, adhesives will usually be necessary to seal the side seams and to close the top and bottom of the sack. Starch glue and PVA glue are the most common adhesives used.

Paper sacks and bags can also include additional non-paper components such as:

- Aluminium foil
- Carry handles
- String closures
- Patched-in windows
- Patched-in plastic netting

As with all packaging materials and solutions, the drive for a circular economy means that there is a requirement to ensure that current and future materials and combinations of materials used for paper sacks and bags are compatible with recycling processes.

DEFINING RECYCLABILITY

According to the Ellen McArthur Foundation, "*A packaging or packaging component is recyclable if its successful post-consumer collection, sorting, and recycling is proven to work in practice and at scale. Recyclable in practice and at scale means that there is an existing (collection, sorting and recycling) system in place that actually recycles the packaging (it is not just a theoretical possibility) that covers significant and relevant geographical areas as measured by population size.*"

Other definitions of recyclability also include reference to the output material from recycling, requiring the recycled end products to "*factually substitute material-identical virgin material in its post-use phase*."
(Institute cyclos-HTP, 2021)

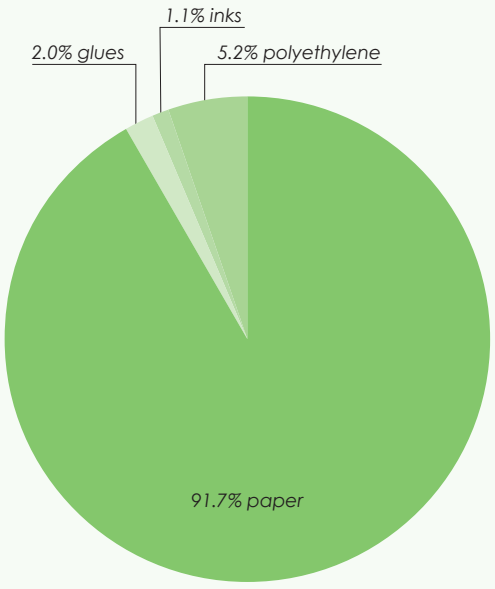
Specifically referring to fibre-based packaging, the definition can be further refined as "*The individual suitability of a paper-based packaging for its factual reprocessing in the post-use phase into new paper and board; factual means that separate collection (where relevant and followed by sorting) into EN 643 grades and final recycling takes place on an industrial scale.*"
(Cepi, ACE, FEFCO, Citpa, 2020)

Thus, to be considered recyclable, collection and processing structures for the packaging format must be available on an industrial scale. This means that it must be possible that the packaging can be collected via the existing collection options and sorted in a qualified manner. Its reprocessability must enable recirculation of the material.

ABOUT PAPER SACK RECYCLING

Paper sacks are a relatively small fraction of the overall paper packaging stream, representing only around 1.5% of all paper packaging in Europe, and less than 1% of total European paper and board consumption. For this reason, there is generally no Europe-wide dedicated separate recycling system for paper sacks. Instead, paper sacks would currently be collected as part of the general paper packaging stream for recycling, making up a small fraction of the overall paper for recycling mix. Paper packaging generally achieves a very high collection and recycling rate in Europe. In 2019, 82% (Eurostat, 2022) of paper packaging in Europe was recycled.

A total of 91.7% of the material used in the construction of paper sacks in Europe is paper, with an additional 2.0% glues and 1.1% inks. The remaining material is mostly polyethylene (5.2%) in the form of a free film. This polymer material will form part of the rejects stream at the recycling mills. Often this material is valorised through energy recovery or disposed of to landfill, but at some mills this material stream may be reprocessed further to generate a recycled polymer stream. This is more prevalent at enhanced recycling mills, where the input of paper for recycling is more homogeneous and therefore the quantities of PE in the rejects stream are more predictable.



Composition of a typical European paper sack.

METHODS AND GUIDELINES RELEVANT TO THE RECYCLABILITY OF PAPER SACKS

Assessing the recyclability of packaging solutions is an emerging discipline. There are several methods and guidelines that are directly relevant for informing design for the recyclability of paper sacks. Table 1 summarises the methods and guidelines which have been referenced in the preparation of this document. As further work becomes available, additional insights will be incorporated into this guidance document.

Method or guideline	Status	Overview	Relevance and application
Circularity by Design Guidance for Fibre-Based Packaging 4evergreen, 2022	Published	4evergreen is a cross-industry alliance with the goal of optimising fibre-based packaging circularity and climate performance. The platform has developed, published and adopted recyclability evaluation protocols, test methodologies and "circularity by design" guidelines for fibre-based packaging. Part I for standard recycling processes was released at the end of February 2022, Part II for deinking and part III for enhanced recycling processes are scheduled for production during 2023. According to the 4evergreen guidelines, packaging consisting of >50% fibre is defined as paper packaging and is included in the scope of the guidance.	Part I of the recyclability evaluation protocol considers standard recycling mill conditions. Part III will mimic "enhanced processes" for recycling of fibre packaging that requires dedicated processes. The first version of Part I of the 4evergreen "circularity by design" guidelines, currently only covering standard mill processes, has provided the basis for the structure of the guidance provided in the document (see section Maximising the recyclability of paper sacks – design recommendations). Where relevant, the guidance in this document aligns with the current 4evergreen guidelines.
Fibre-based Packaging Recyclability Evaluation ProtocolCITATION 4Ev22 \l 2057 4evergreen, 2022	Version considered: Part 1, Beta Release December 2022	This document describes the assessment procedure and score calculation of the recyclability of individual fibre-based packaging items and/or materials, considering conditions at a standard recycling mill.	The method and the supporting scorecard have been referred to in defining the factors influencing the recyclability of paper sacks and in defining conditions where additional testing may be required in order to demonstrate recyclability. The five basic constructions described in these guidelines that are representative of >80% of the paper sacks on the market have been subjected to assessment in accordance with the protocol. The results of the testing have fed into the recommendations for maximising the recyclability of paper sacks presented in these guidelines.
The German minimum standard for determining the recyclability of packaging 2022 (hereby referred to as the German Minimum Standard) Stiftung Zentrale Stelle Verpackungsregister, 2022	Version considered: 31 August 2022	This document defines the minimum requirements for Packaging Recovery Organisations (PRO) to measure recyclability with respect to setting lower/higher compliance fees for individual packaging formats. Measurement and classification is made by each PRO separately. PROs can add individual additional criteria and therefore the recyclability result of the same pack may vary between different PROs.	This document takes a holistic approach to quantifying recyclability (collection, sorting, reprocessing) and quantifies the proportion of a package that is recyclable. It does not specifically address paper sacks but addresses mixed paper packaging streams. The document has been referred to in defining the factors influencing the recyclability of paper sacks when compiling the guidance provided in this document (see section Maximising the recyclability of paper sacks – design recommendations).

Method or guideline	Status	Overview	Relevance and application
The verification and examination of recyclability: Requirements and assessment catalogue of the Institute cyclos-HTP for EU-wide certification (hereby referred to as the Institute cyclos-HTP method) Institute cyclos-HTP, 2021	Version considered: Revision 5.0, 2021	Institute cyclos-HTP assesses and certifies the recyclability of packaging and goods. To facilitate this, they have developed a conceptual framework as well as a catalogue of requirements and assessment criteria for the examination and verification of recyclability. The cyclos-HTP assessment fulfils the minimum standard without exemptions.	This document takes a holistic approach to recyclability (collection, sorting, reprocessing) and quantifies the proportion of a package that is recyclable. It does not specifically address paper sacks but addresses mixed paper packaging streams. The document has been referred to in defining the factors influencing the recyclability of paper sacks when compiling the guidance provided in this document (see section Maximising the recyclability of paper sacks – design recommendations).
Paper-based packaging recyclability guidelines Cepi, ACE, FEFCO, Citpa, 2020	Published	These guidelines have been developed by the main trade associations representing fibre-based packaging to improve the recyclability of paper packaging products in the paper recycling process.	The guidelines provide a high-level view of the relevant factors influencing the recyclability of fibre-based packaging. They have been used to inform the definition of design features and materials relevant specifically to paper sack design and recyclability investigated in more depth in this document.
Design guidance for recyclability – a resource for paper-based packaging designers AF&PA	Published	Guidance to support the paper-based packaging manufacturing supply chain to design and manufacture recyclable packaging. Kraft paper sacks and multiwall shipping sacks are listed with other recyclable paper-based packaging.	The guidelines provide a high-level view of the relevant factors influencing the recyclability of paper sacks. They have been used to inform the definition of design features and materials relevant specifically to paper sack design and recyclability investigated in more depth in this document.
Paper and board recyclability guidelines CPI 3rd Edition, August 2022	Published	Guidelines to assist retailers and brands to specify and design packaging that can be easily processed in high volume paper mills with current "standard" pulping technology.	The guidelines provide a high-level view of the relevant factors influencing the recyclability of paper sacks. They have been used to inform the definition of design features and materials relevant specifically to paper sack design and recyclability investigated in more depth in this document. They have informed the definition of recommended composition limits for, e.g. free film content, etc.
The Aticelca 501 Test Aticelca, 2019	Published	The Aticelca 501 Test is an assessment method capable of determining the level of recyclability of mainly cellulosic materials and products (paper and cardboard). It is a laboratory-based analysis which became the UNI 11743:2019 standard in April 2019. The analysis simulates the main phases of the industrial processing of recovered paper to be recycled up to producing a new sheet of paper. The result of the laboratory test, which analyses the main elements that characterise the recyclability of paper and board, are summarised by an index expressed by the letters A+, A, B and C, being A+ the highest recyclability level.	The five basic constructions described in these guidelines that are representative of >80% of the paper sacks on the market have been subjected to the Aticelca 501 test. All five constructions were deemed to be recyclable to some degree according to the test. The results of the tests have fed into the recommendations for maximising the recyclability of paper sacks presented in these guidelines.

Method or guideline	Status	Overview	Relevance and application
Recyclability CTP Test Method CTP-REC21 Centre Technique du Papier, 2021	Proprietary test method	This is a laboratory-based test method developed to demonstrate that packaging is compliant with the requirements for packaging recoverable by material recycling (EN 13430), as specified by the Essential Requirements contained within the Packaging and Packaging Waste Directive (94/62/EC).	The requirements of this test methodology have been considered when defining the design features and materials relevant specifically to paper sack design and recyclability investigated in more depth in this document.

Table 1: Methods and guidelines considered in the preparation of this document

MAXIMISING THE RECYCLABILITY OF PAPER SACKS – DESIGN RECOMMENDATIONS

As a predominantly fibre-based packaging solution, paper sacks are inherently recyclable. Nonetheless, there are still characteristics of paper sack structures and designs which may influence the recyclability of individual paper sacks in standard and/or special recycling mills.

These design features are summarised in Table 2 below.

Feature/material	Potential influence on recyclability
Wet-strength agents	By definition, wet-strength agents reduce the susceptibility of the board to wettability. As the fibre recovery process relies on hydraulic forces to separate the fibres, then wet strengths have the potential to reduce the yield from the fibre recovery process.
Barrier films (free films)	Some paper sack configurations include a polymer-free film layer (currently usually PE, but also other polymers are possible). This PE-free film layer will be separated out as part of the reject stream at the recovered-paper mill.
Barrier coatings	Coatings can provide sack kraft paper with resistance to water vapour/moisture penetration. As the fibre recovery process relies on hydraulic forces to separate the fibres, then water-resistant coatings have the potential to reduce the yield from the fibre recovery process. According to the German Minimum Standard, a wax coating is not considered as an incompatibility, but the dissolvability has to be measured with an appropriate test method. In the Institute cyclos-HTP method, the products need to be dissolved under the technical operating parameters in typical reprocessing facilities. Wax-coated sack kraft papers would not achieve the same dissolution rate in water as standard paper sacks. Recyclability would need to be determined through measurements, according to the relevant testing methodology.
Laminations	As with coatings, films can be laminated to the sack kraft paper to provide additional barrier properties. To facilitate recyclability, these lamination films need to be easily separated from the sack kraft paper in the fibre recovery process, otherwise fibre yield will be reduced as fibre will be lost along with the barrier lamination as part of the reject stream at the recovered-paper mill. Two-sided laminated paper can be particularly challenging for recycling, as water cannot penetrate into the fibres.
Adhesives	Adhesives are integral to the manufacture of packaging and standard paper recycling mill technology is designed to separate and remove these during the papermaking process. However, some adhesives have potential to soften or plasticise in the heat of the process to form "stickies" that can end up on the finished paper, spoiling the performance and appearance of the paper and/or the papermaking or converting processes. The German Minimum Standard lists water-insoluble or re-dispersing adhesive applications as incompatible with recycling processes where it has not been specifically proven that they can be removed. The Institute cyclos-HTP method also identifies insoluble dispersing adhesives as incompatible with recycling processes, unless it can be proved that they are removable by INGEDE Method 12 or 4.
Printing inks	Inks can pass into the new sheet, causing flecking, visual impurities, dirt specks and pin holes, thereby reducing the quality of the recycled product. However, the ink coverage on paper sacks is minimal compared to most other paper and board products, and the printing inks and varnishes typically used are compatible with standard recycling processes. According to the Institute cyclos-HTP method, EuPIA provides an exclusion list for printing inks and related products that are contaminants and not separable by the recycling processes.
Other components	Other components can include plastic windows, string closures, handles, etc. These other materials will be separated out as part of the reject stream at the recovered-paper mill.

Table 2 Design features and materials and their implications for the recyclability of paper sacks

The paper sack structure and design features which can potentially influence recyclability were identified through the following processes:

- Parameters identified through reference to the German Minimum Standard (Stiftung Zentrale Stelle Verpackungsregister, 2022) and Institute cyclos-HTP (Institute cyclos-HTP, 2021) recyclability assessment methods and various recyclability test methods (4Evergreen, 2022), (Aticelca, 2019) and (Centre Technique du Papier, 2021).
- Literature review and consideration of other design for recyclability guidelines (GreenBlue, 2011), (CPI, 2022), (Cepi, ACE, FEFCO, Citpa, 2020), (CEFLEX, 2020) and (FEFCO, 2021).
- Interviews with stakeholders, including suppliers of sorting technology, operators of standard recovered paper mills and suppliers of enhanced repulping equipment.

In this section, we discuss the relevance of each of these parameters and identify actions that could be taken to maximise the recyclability of paper sack materials and designs. Each specific structure or design component was then assessed against the categories outlined in Table 3.

Fully compatible with standard recycling processes	Conditionally compatible with standard recycling processes	Not compatible with standard recycling processes unless testing proves otherwise	Compatibility with recycling processes unknown – testing required to prove recyclability
Paper sacks containing these elements are fully compatible with existing sorting technologies, they do not disturb fibre recovery through standard or enhanced recycling processes. This is demonstrated through existing test results and/or practical experience.	Paper sacks containing these elements are still sortable and recyclable but are seen as less favourable for either standard or enhanced fibre recovery processes as they make the process more difficult or reduce the quality of the output material. Specific testing can demonstrate that these constituents do not negatively impact recycling.	Paper sacks containing these elements either cause major issues during sorting and/or recycling or render the quality of the output material from recycling processes unusable. Paper sacks containing such elements are therefore considered unrecyclable, unless recyclability can be proved via relevant testing.	The recyclability implications of paper sacks containing these elements is unknown and further research and/or testing is required to establish compatibility with existing sorting processes, the enhanced fibre recovery process and standard recycling processes.

Table 3 Categories considered for the recyclability implications of different compositions and design components, adapted from (4evergreen, 2022)

Fibres used in kraft paper sacks

Brown or white sack kraft paper is made from long virgin fibre, which imparts the high strength properties to the paper. The recovered fibres from used paper sacks are desirable in the manufacture of a wide range of recycled-content packaging grades such as corrugated case medium and core board.

Component	Subcategory	Recyclability	Implications for recyclability
Fibres used in sack kraft paper	Sulphate kraft, white	**Fully compatible with recycling processes**	No implications for the recyclability – all fibre types used in paper sacks are recyclable in the dedicated fibre recovery processes operated across Europe
	Sulphate kraft, brown	**Fully compatible with recycling processes**	

Additives and agents used in sack kraft paper

Sack kraft paper is made from long white or brown virgin fibres which are subjected to refining to increase fibrillation and surface area for hydrogen bonding to maximise paper sheet strength. This paper grade is distinguished by its high cellulose fibre content. Stock additives, where needed, are carefully selected so as not to reduce the inherent fibre bonding strength.

Stock additives

Retention aids, such as polyacrylamide, are used to retain the shorter fibres in the paper sheet which might arise during refining. They are not intended to have any impact on the sack kraft sheet properties.

Dry strength additives such as carboxymethyl cellulose might be added to increase sheet dry strength, such as tensile energy absorption, tensile strength and burst strength. Wet-strength agents such as polyamide epichlorohydrin and glyoxalated polyacrylamide might be added to the stock to ensure that sheet strength is retained when the paper sack is to be used in contact with moist produce. Colourants can also be added to the stock to ensure consistent shade.

Sheet surface additives

Surface sizing agents such as starch can be applied in line to the pressed paper sheet to improve sack printability, for instance to improve the definition of a printed bar code.

Binders in dispersion coatings can be applied in line to the pressed paper sheet to improve printability, for instance for eight-colour all over printed plies used with branded pet food.

Component	Subcategory	Recyclability	Implications for recyclability
Stock additives			
Retention polymers	Polyacrylamide	**Fully compatible with recycling processes**	
	Polyaluminium chloride	**Fully compatible with recycling processes**	
Dry strength	CMC	**Fully compatible with recycling processes**	
	Starch	**Fully compatible with recycling processes**	
Wet-strength	Polyamide epichlorohydrin (PAE)	**Conditionally compatible with standard recycling processes**	Overall, permanent wet-strength paper is not considered compatible with standard recycling mill processes when included in large quantities in the recovered paper mix. Potential for recyclability depends on a number of factors, such as relative wet-strength (WS) level, amount of WS agent, etc. Subsequently, minimising or avoiding these wet-strength resins can make the recycling process more efficient, facilitating lower pulping temperature and time, and reduced chemicals usage, etc. Further testing may be required to demonstrate the fibre yield from sack kraft paper containing PAE as a wet-strength resin to demonstrate recyclability or otherwise.
	Glyoxalated polyacrylamide	**Fully compatible with recycling processes**	
Colourants	Colourants/dye for shading	**Fully compatible with recycling processes**	
	Colourants/pigments	**Fully compatible with recycling processes**	Physically recyclable but certain dyes are not approved for food packaging applications and such dyes should be avoided.
Sheet surface additives			
Sizing agents	Starch	**Fully compatible with recycling processes**	
Binder	S/B latex	**Fully compatible with recycling processes**	
	S/A latex	**Fully compatible with recycling processes**	Depending on amount, adhesive strength, etc.
	Starch bio-binder	**Fully compatible with recycling processes**	

Non-fibre components – barrier films (free films), barrier coatings and adhesive laminated films

For some applications, kraft paper sacks need a functional barrier or surface coating to protect food and non-foods from external factors such as water and water vapour, oxygen ingress, etc. These functional barriers also retain product moisture, shelf life-extending modified atmospheres and prevent pack damage from oily and greasy produce. The techniques that are used to functionalise kraft paper sacks include:

- Free films
- Coatings
- Lamination
- Production of a paper-aluminium composite

Currently, the majority of polymers used for free films and extrusion coatings are polyethylene (both high density (HDPE) and low density (LDPE)). Other polyolefins are also used (e.g. polypropylene and EVOH, amongst others). However, paper sack producers are constantly investigating alternative polymers, particularly bio-based and biodegradable polymers. It is important that paper sack designers and manufacturers consider recyclability in the early stages of the design process and, at the same time, are able to continue to innovate and to investigate alternative materials and solutions which may offer improved functionality and reduced environmental impact. The impact on recyclability needs to be assessed during the innovation process.

Component	Subcategory	Recyclability	Implications for recyclability assessment
Free film	Polyethylene (PE) – fossil-based and bio-based[1]	**Fully compatible with standard recycling processes**	PE-free film barriers allow fibre dispersion. The PE film is less dense than cellulose fibre and water, allowing it to be captured by the mill's cleaning processes. The proportion of PE within the overall packaging composition should be minimised and should ideally be less than 10% of the pack weight – a level that does not interfere with the recyclability of the kraft paper sacks in standard recycling mills. Higher levels, up to 20%, are possible but, in this case, testing is recommended to ensure compatibility with the standard recycling mill processes. If polymers other than PE are used, then compatibility with the recycling process will depend upon the density of the polymer in question. Polymers with low shear strength that break down in the pulper into microplastics should also be avoided because microplastics may pass through mill wastewater cleaning systems and be discharged into water courses or pass into and contaminate the finished product. For biodegradable polymers, the material is unlikely to have sufficient time to degrade before it passes through the repulping and papermaking process.
	Other fossil-based and non-fossil-based non-biodegradable films	**Compatibility with standard recycling processes unknown – testing required to prove recyclability**	
	Fossil-based and bio-based biodegradable polymers	**Compatibility with standard recycling processes unknown – testing required to prove recyclability**	

[1]The majority of PE used is fossil-based PE. However, bio-based PE is also available. Bio-based PE is functionally equivalent to fossil-based PE but is derived from biological matter (e.g. sugarcane or tall oil) rather than fossil fuels. Bio-based PE has the same properties as fossil PE and behaves in the same way in recycling processes.

Component	Subcategory	Recyclability	Implications for recyclability assessment
Barrier coating	Thermoplastic (one side coated – inside the pack only)	**Fully compatible with standard recycling processes**	An outside coating may affect the sorting process (as it is detected by NIR). In only very few cases is the inside lamination detected by NIR. For internal thermoplastic coating, the method is considered fully compatible with recycling. For external thermoplastic coating, the method is considered conditionally compatible with recycling. In either case, the proportion of non-fibre material (lamination film plus adhesive) within the overall packaging composition should be minimised and should ideally be less than 10% of the pack weight – a level that does not interfere with the recyclability of the kraft paper sacks in standard recycling mills. Higher levels, up to 20%, are possible but in this case, testing is recommended to ensure compatibility with the standard recycling mill process.
	Thermoplastic (one side coated – outside the pack only)	**Conditionally compatible with standard recycling processes**	
	Thermoplastic (two-side coated/ laminated)	**Not compatible with standard recycling processes unless testing proves otherwise**	Two-sided laminates are more challenging to recycle in standard paper mills and should be collected and reprocessed separately for recycling in special recycling mills.
	Wet barrier coatings (dispersion coatings)	**Conditionally compatible with standard recycling processes**	This includes aqueous polymer dispersions (e.g. EEA, SB, ABS, PVDC, etc), solvent-based coatings and water-soluble coatings. For any wet barrier coatings, testing is required. For aqueous polymer dispersions (which may include acrylics), the properties of the polymer dispersions depend on the amount and strength of the adhesive and the presence of fillers. Water-soluble coatings require thorough cleaning in the milling to prevent issues such as foam forming. The COD load will be higher for soluble polymers.
	Wax/paraffin coatings – dipping of paper in molten wax (two sided)	**Not compatible with standard recycling processes unless testing proves otherwise**	May impact on stickiness and cause screen clogging, challenging to recycle in standard paper mills. According to the German Minimum Standard, a wax coating is not considered as an incompatibility, but the dissolvability has to be measured with an appropriate test method. In the Institute cyclos-HTP method, the products need to be dissolved under the technical operating parameters in typical reprocessing facilities. Wax-coated sack kraft papers would not achieve the same dissolution rate in water as standard paper sacks. Recyclability would need to be determined through measurements, according to the relevant testing methodology.
Lamination with polymers (extrusion lamination and adhesive lamination)	Two-sided laminates	**Not compatible with standard recycling processes unless testing proves otherwise**	Two-sided laminates are more challenging to recycle in standard paper mills and should be collected and reprocessed separately for recycling in special recycling mills.
	Adhesive lamination with PE or other thermoplastics	**Conditionally compatible with standard recycling processes**	Some adhesives can penetrate the paper sheet that can lock in fibre and prevent dispersion during repulping, which reduces fibre yield. Adhesives can increase the potential of stickies. Whilst some laminating adhesives facilitate fibre dispersion, the initial consensus is that this product has limited recyclability, but further test results are needed (courtesy of the Cepi Harmonised European Laboratory Test Method). The proportion of non-fibre material (lamination film plus adhesive) within the overall packaging composition should be minimised and should ideally be less than 10% of the pack weight – a level that does not interfere with the recyclability of the kraft paper sacks in standard recycling mills. Higher levels, up to 20%, are possible but in this case, testing is recommended to ensure compatibility with the standard recycling mill process.
	Adhesive lamination with water-soluble adhesives	**Fully compatible with standard recycling processes**	For preference, the industry would wish that laminates be lightly bonded with a water-soluble adhesive agent, so that the plastic layer separates easily in the paper pulping process. Needs thorough cleaning in the milling to prevent issues such as foam forming. The COD load will be higher for soluble polymers. The proportion of non-fibre material (lamination film plus adhesive) within the overall packaging composition should be minimised and should ideally be less than 10% of the pack weight – a level that does not interfere with the recyclability of the kraft paper sacks in standard recycling mills. Higher levels, up to 20%, are possible but in this case, testing is recommended to ensure compatibility with the standard recycling mill process.

Component	Subcategory	Recyclability	Implications for recyclability assessment
Paper-aluminium composite	Lamination with PE-aluminium foil	**Conditionally compatible with standard recycling processes**	Testing required. May have a "stardust" effect in visual appearance.
	Metallisation (direct or transfer)	**Conditionally compatible with standard recycling processes**	

Inks and varnishes

Kraft paper sacks are printed using the flexography printing process. Most inks and varnishes used are water-based, solvent-based or UV-cured inks, and varnishes are used occasionally. These ink systems are considered compatible with fibre recycling processes. Insoluble ink particles which are dispersed during the repulping process are recovered into the paper sheet.

There is no evidence that inks and varnishes containing MOSH (Mineral Oil Saturated Hydrocarbons), MOAH (Mineral Oil Aromatic Hydrocarbons) and phthalates are used in the European paper sack sector. However, as the presence of these chemicals can significantly reduce the future uses of recycled paper and board, paper sack producers and specifiers should take particular care to ensure that raw materials are regularly verified and if the chemicals are detected the materials are not accepted.

Component	Subcategory	Recyclability	Implications for recyclability assessment
Inks and varnishes	Water-based	**Fully compatible with standard recycling processes**	
	Solvent-based		
	UV-cured		UV inks and varnishes can cause issues within some papermaking processes, as they are not readily removed by most conventional de-inking technology. Where they are used in packaging they can be recycled, albeit they can cause flecking on the new paper sheet. For this reason, the industry would prefer to keep to a minimum the quantities of cured varnished material (either conventional or UV-cured) specified in packaging products.

Adhesives

As they make up only a small weight percentage of any given item, adhesives themselves are today not the target of any recycling process and they are therefore not considered "recyclable" as such. At the same time, the adhesives can impact on the yield and quality of the paper recycling process. Consequently, adhesives should be suitably compatible with recycling processes to allow successful and effective recycling of the paper. Compatibility refers to adhesive applications being designed in such a way that they neither cause unacceptable impacts on the recycling process nor unacceptably deteriorate the quality of the output.

As a general principle, as for all non-target materials of the recycling process, the amount of adhesives used in any given paper sack should be optimised to the minimum required to achieve its function. Doing so will minimise the amount of adhesive that the recycling process needs to handle. To facilitate easy removal of adhesive applications, they should, where technically possible, be made large enough to be screened out effectively. Very thin adhesive applications should be avoided because they could be less resistant to shear forces introduced in pulping, resulting in very small particles that cannot be removed by screening.

Besides laminating adhesives used to adhere polymer barrier layers to sack kraft paper, other adhesives may be used in the construction of paper sacks including hot-melt adhesives (typically polyvinyl acetate (PVA)) and starch-based adhesives to seal closures and side seams. Hot-melt adhesives may also be used for window patching. In some cases, polyurethane adhesives may also be used.

Hot-melt adhesives are not water soluble. By keeping their application size suitably large, hot-melt applications can be removed effectively during screening (European Paper Recycling Council, 2017). Furthermore, hot melts exhibit tackiness only above their softening point. Thus, by choosing hot melts with a suitably high softening point, i.e. >68 °C (above the temperatures encountered in paper recycling), secondary micro-sticky and macro-sticky formation can be minimised.

There is no evidence that adhesives containing MOSH (Mineral Oil Saturated Hydrocarbons), MOAH (Mineral Oil Aromatic Hydrocarbons) and phthalates are used in the European paper sack sector. However, as the presence of these chemicals can significantly reduce the future uses of recycled paper and board, paper sack producers and specifiers should take particular care to ensure that raw materials are regularly verified and if the chemicals are detected the materials are not accepted.

Component	Subcategory	Recyclability	Implications for recyclability assessment
Adhesives	Starch-based, PVA, acrylic, polyurethane	**Fully compatible with standard recycling processes**	Any water-soluble adhesive application can be expected to dissolve into the process water during the fibre repulping process. These materials will become, and remain, part of the process water throughout the further processing steps (4evergreen, 2022). Hot melts exhibit tackiness only above their softening point. Thus, by choosing hot melts with a suitably high softening point, i.e. above the temperatures encountered in paper recycling secondary micro-sticky formation can be minimised (4evergreen, 2022).
	Hot-melt adhesives	**Conditionally compatible with standard recycling processes**	Hot melts exhibit tackiness only above their softening point. Thus, by choosing hot melts with a suitably high softening point, i.e. above the temperatures encountered in paper recycling secondary micro-sticky formation can be minimised (4evergreen, 2022). For hot-melt adhesives with a melting point <68 °C, there is potential to cause generation of stickies in the products manufactured from the recovered fibres, thereby reducing quality. Testing is required where it has not been specifically proven that these applications can be removed. As an alternative to testing, removability can be estimated using the EPRC assessment methodology described in the Scorecard for the Removability of Adhesive Applications, which could be applied to determine removability (European Paper Recycling Council, 2017).
	Pressure sensitive applications (self-adhesive labels, tapes)	**Conditionally compatible with standard recycling processes**	Paper sack manufacturers are generally not specifying and applying self-adhesive labels. However, these may be applied by downstream stakeholders (in particular fillers). Some pressure-sensitive labels may incorporate phthalates, which can significantly reduce the future uses of recycled paper and board. Therefore, particular care should be taken to ensure that the adhesive for pressure-sensitive labels does not include phthalates in its make-up.

Additional components

Paper sack converters offer several packaging aids, such as patched-in plastic windows and handles. Such non-paper components can interfere with NIR identification of the paper sack leading to its removal from the paper stream for recycling. If the paper sack is recognised by the sorting equipment, the non-paper components contaminate the fibre stock and have to be removed by the mill's cleaning system. Non-paper rejects must be disposed of to landfill or waste to energy, which increases mill reprocessing costs. Where possible, all non-paper components should be designed out.

Component	Subcategory	Recyclability	Implications for recyclability assessment
Packaging aids	Carrying handles	**Conditionally compatible with standard recycling processes**	» Potentially interfere with NIR recognition of the package as paper-based. » Form part of the mill rejects stream.
	Patched-in plastic windows		
	Patched-in plastic netting		
	String closure/opening mechanisms	**Conditionally compatible with standard recycling processes**	» Form part of the mill rejects stream.

Design for separability

In some cases, the various layers in paper sacks are designed to be separable. For example, sacks for chemical products used in a sterile environment such as pharmaceuticals production or, in some cases, for hygeine reasons to avoid food contamination may consist of an LDPE sack placed inside a paper sack, with each being easily separable from the other before use in the controlled area.

In such cases, the recylability of the separated components needs to be considered invidiually as each component can potentially be handled in the waste management system separately.

Design to reduce unintended product residues

Paper sacks are used to pack a wide range of dry food produce such as flour and pet food. Food residues need to be removed from paper sacks which are to be recycled to:

- Reduce microbial growth which can contaminate the finished paper product
- Reduce the risk of infestation from insects and rodents
- Reduce the organic content within mill process waters and effluent treatment costs

Minor contamination/staining is tolerated by recyclers. It also is in the interests of the end-user to remove all the produce they have purchased. Sack design should therefore enable the easy shaking out of contents, particularly by avoiding closures which can trap produce.

Labelling and communication

These guidelines address recyclability from the perspective of the packaging supplier and what can be done regarding the materials used and the physical construction of the paper sacks. Packaging suppliers have limited influence over the graphical design and information carried on the final package. However, aiding recyclability is a responsibility of all actors in the value chain. Fillers/brand owners should be encouraged to provide appropriate information to end-users regarding what to do with sacks at end-of-life. Particular considerations include:

- Where recycling is a desirable end-of-life solution for paper sacks, the sacks should be clearly marked as recyclable. The end-users should be instructed to fully empty sacks before placing them in the recycling stream, as residues are a significant impediment to recycling. Appropriate graphics and text should be used to convey these messages.

- Paper sacks are used to pack a wide range of products, including hazardous materials and dangerous goods (e.g. certain chemicals, fertilisers, pesticides, etc). For paper sacks which have contained these products, incineration with energy recovery may be the most appropriate end-of-life solution as any product residues could contaminate the recycled fibre stream and limit the applications for which the recycled paper could be used. Appropriate graphics and text should be used to make the end-user aware that these paper sacks should not be placed in the recycling stream.

Packaging suppliers should work with, and be ready to provide advice to, their customers on appropriate labelling and communication.

FUTURE-PROOFING THESE GUIDELINES

Technology and policy relating to collection, sorting and recycling is fast moving:

- Capabilities in sorting systems and reprocessing technologies are constantly changing. Existing technologies are evolving, and new technologies are emerging which could revolutionise recycling value chains. CEPI Eurokraft and EUROSAC maintain a watching brief on those technologies pertinent to paper sack collection, sorting and recycling.

- The legal requirements and definitions of recycling are under constant review, particularly as policies relating to the EU's Circular Economy Action Plan are finalised.

- Also, other design for recycling guidance is being developed and revised which may provide further insights regarding the recyclability of paper sacks.

These guidelines will therefore be reviewed regularly and updated as necessary to reflect the dynamic situation. Users of the guidelines are encouraged to check that they are accessing the most recent version.

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MORE INFORMATION

Paper Sacks – Design for Recyclability Guidelines, 1st edition

Prepared by RISE Bioeconomy & Health on behalf of CEPI Eurokraft and EUROSAC

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