TECHNICAL GUIDANCE

Designing Garments for Textile-to-Textile Recyclability

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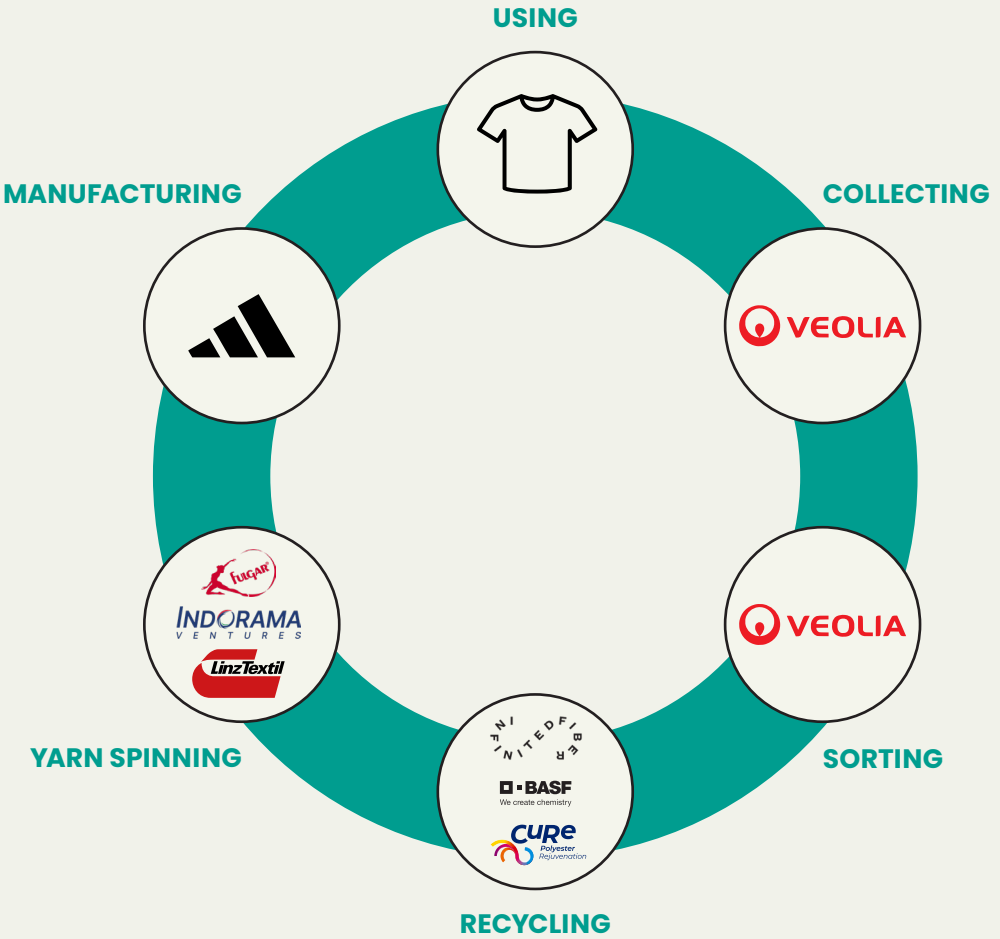
T-REX PROJECT



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Co-funded by the European Union

Textile Recycling Excellence Project (T-REX) was a three-year research project, active from 2022-2025, funded by the European Union's Horizon Europe research and innovation programme. Thirteen partners from across the value chain came together to collaborate towards demonstrating a potential scalable solution for textile-to-textile recycling. This involved the collection, sorting and pre-processing of household textile waste to demonstrate the chemical recycling process of **cotton, polyester and polyamide 6** from waste into new garments.

SUPPORTING TOPICS

LKT · Quantis A BCG COMPANY · Aalto University School of Arts, Design and Architecture · ARAPAHA · FASHION FOR GOOD

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Learn about the industrial processes involved in textile recycling

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INTRODUCTION

The apparel industry is facing growing pressure to shift the way it currently makes, uses and disposes of clothing. Emerging technologies, changing consumer expectations and new policies are laying the foundations to move from a linear to a **circular industry**.

The research conducted in the T-REX Project explores how we can best design garments to accelerate circularity. This Technical Guidance brings together the key insights from the project. It offers practical guidance on how to create recyclable garments while **stepping away from the mono-material approach**.

More specifically, the document contains detailed guidance to **improve the recyclability of garments made from cotton, polyester and polyamide 6**. This information is based on the **chemical recycling** technologies of T-REX project partners Infinited Fiber Company, CuRe Technology and BASF, respectively.

As design is at the core of the industry, **designers and material developers can become a driving force** behind the transition to a circular apparel industry. This guidance aims to equip them with the tools to create recyclable products in a realistic and impactful way. Since circularity requires industry-wide collaboration, we encourage all stakeholders interested in a circular apparel industry to explore this Technical Guidance.

DESIGNING FOR CIRCULARITY

This Technical Guidance focuses specifically on material and product development for chemical recycling. However, it is important to be aware of the **wider scope of circular approaches**, as together they are the preferred alternative to the linear 'take, make, dispose' model.

Whilst the three main principles to design for circularity are all important, they should be utilised and prioritised according to the intended use of the product. Since **the ideal circular clothing item would consider not one but all of these design approaches**, they should be seen as complementary, rather than mutually exclusive.

THREE MAIN PRINCIPLES TO DESIGN FOR CIRCULARITY:

DEMAND

Designing for demand means only using resources when there is a need for it, by focussing on the product purpose, minimising over-production and reducing the impact of the materials and production processes.

DURABILITY

Design for durability will increase the lifespan of a garment by focussing on the physical and emotional longevity of products, together with their repairability and reusability.

RECYCLABILITY

Design for recyclability prevents waste generation by ensuring clothing can be processed into raw materials for the production of new garments.

PART 1

KNOWLEDGE BASE

This part **explores the main processes involved in textile-to-textile recycling** that are important to know from a design perspective.

Having a basic understanding of these processes will provide context to the design recommendations in Part 2.

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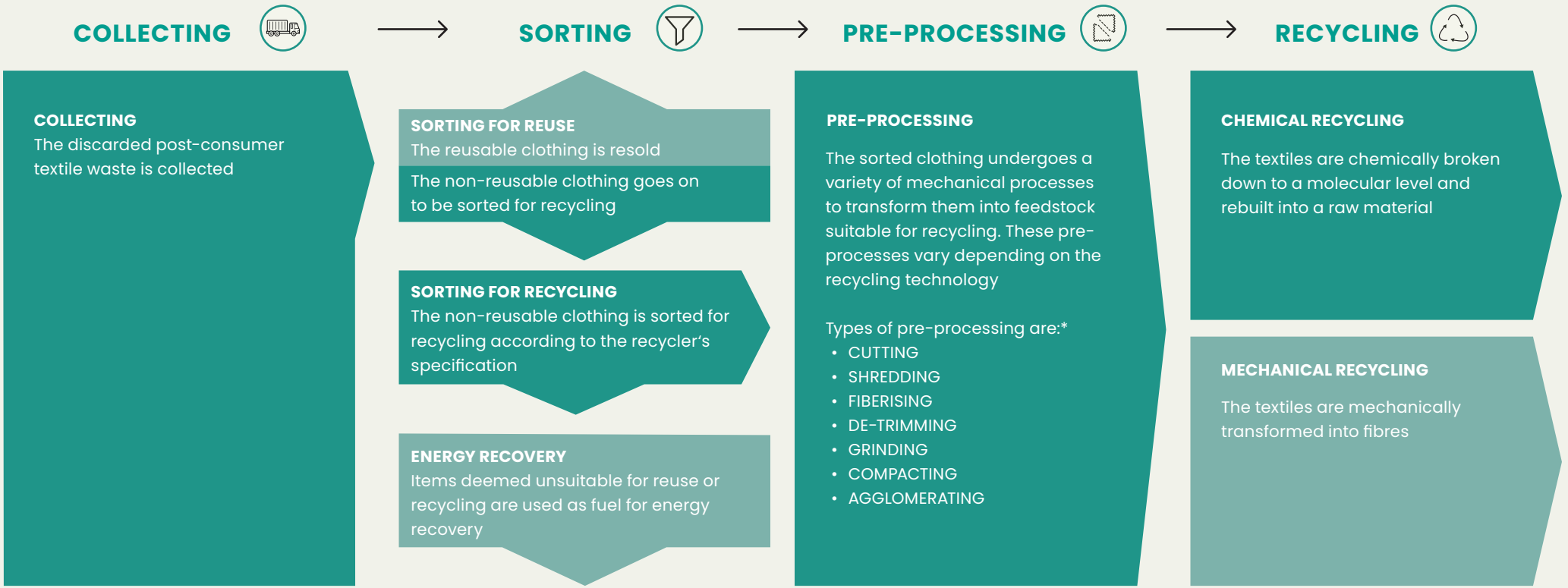
OVERVIEW OF THE TEXTILE RECYCLING PROCESS

Post-consumer textile-to-textile recycling is a multi-step process: when discarded clothes are collected, they go through several processes before they can be recycled.

An overview of how clothing flows through these processes can be found below. The following pages go into more detail on these processing phases and how they influence a garment's recyclability.



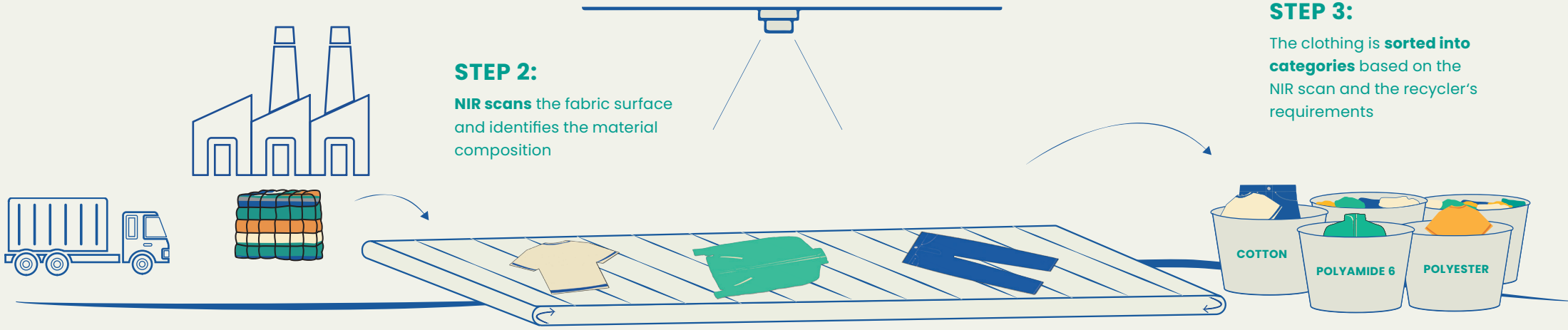
*See explanation in glossary (p.28)

SORTING FOR TEXTILE-TO-TEXTILE RECYCLING

When the collected clothing arrives at the sorter, it is first assessed on reusability. Afterwards, the **non-reusable items** are sorted for recycling, as shown below. In this process, **NIR (Near-Infrared) technology** is used to scan the fabric surface with infrared light to identify the fabric composition. Based on the outcome of this scan, a match with recycler's requirements is made. **NIR is an important indicator of how to design for recyclability:**

- Blended materials decrease accuracy of NIR scanning
- Finishes and coatings cannot be detected by NIR
- Garment elements with a different composition to the main fabric (like elbow patches and pocket bags) can go unnoticed as NIR only scans specific points
- The overall composition of multilayer garments is difficult to detect as NIR only scans the garment surface

Part 2: Design Toolbox, will go into detail on how fabric selection and garment design can have a positive impact on the sorting efficiency.



STEP 1:

Non-reusable clothing arrives for sorting at the recycling station

STEP 2:

NIR scans the fabric surface and identifies the material composition

STEP 3:

The clothing is **sorted into categories** based on the NIR scan and the recycler's requirements

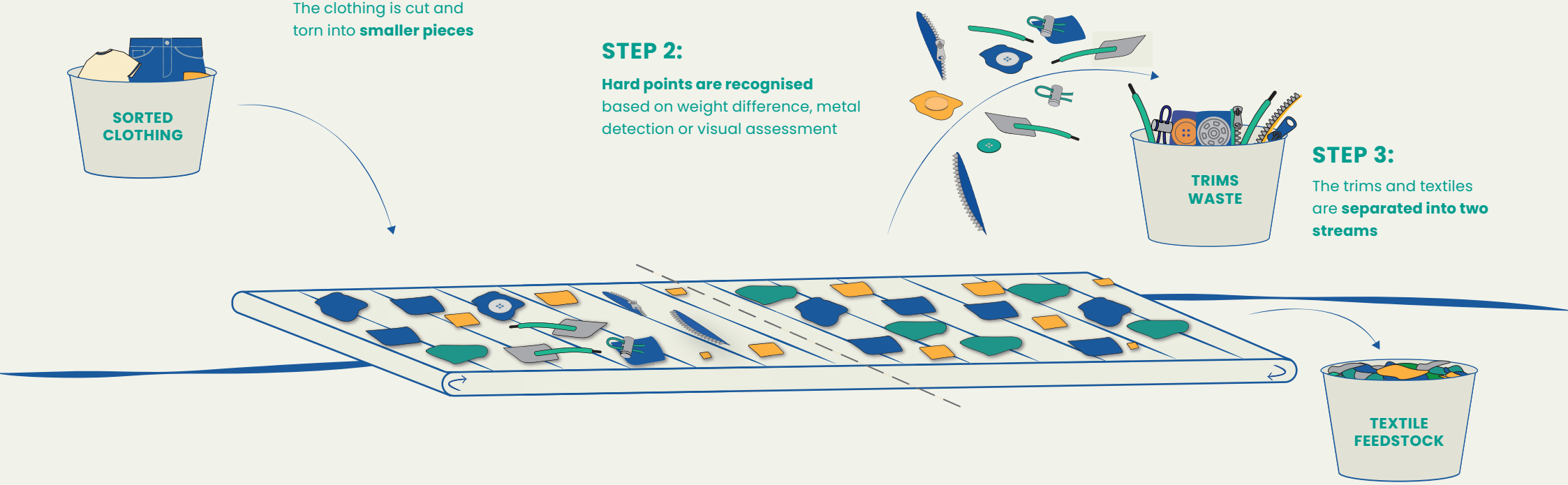
DE-TRIMMING: PREPARATION FOR RECYCLING

Pre-processing encompasses all steps that sorted clothes go through before they can be recycled. **From a design perspective, de-trimming is the most important step to be familiar with.** The purpose of the process is to remove the trims (buttons, labels, zippers, etc.) from garments, which would be problematic during recycling. It is often done manually, but **automated de-trimming techniques are being developed to remove trims more efficiently.** The process flow of automated de-trimming is shown below.

De-trimming can result in significant material loss as some fabric often stays attached to the trims when removing them. **Designers can therefore positively influence the process by reducing trims where possible**. More details on trim usage can be found in **Part 2: Design Toolbox**

DEBUNKING MYTHS

Detachable trims are often considered better for recyclability. In reality, they don't have much impact as industrial scale pre-processors don't have time to manually check and remove detachable trims



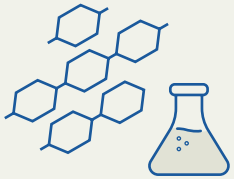
CHEMICAL RECYCLING

Chemical recycling is particularly effective in processing mixed-material textile waste, which is difficult to recycle using traditional mechanical or thermo-mechanical methods. Chemical recyclers apply advanced technologies to break down textile waste into its basic chemical building blocks and re-build new raw material from there. The process includes purification where **colorants and a selective range of contaminants are removed**.

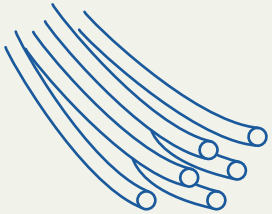
The recovered high-quality materials can replace virgin materials in the creation of new textiles. **With chemical recycling in mind, designers can be more flexible in the use of material blends, colours and trims compared to other recycling technologies**. More detail on which material blends and contaminants can be handled based on the technical capabilities of specific recycling technologies can be found in **Part 2: Design Toolbox**.

DEBUNKING MYTHS

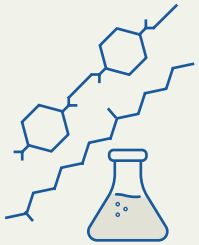
You may associate the word „chemical" in **chemical recycling** with „toxic". In reality, everything we see and touch is made of chemicals. So don't be alarmed - it isn't toxic, it's just molecules.



Captured and **purified** cellulose gets **dissolved** to a molecular level



Dissolved cellulose is **spun** into man-made cellulosic filaments and cut into **staple fibre** length



Polymers get **depolymerised** to a molecular level and **purified**

Molecules are **repolymerised** into polymer chains, extruded and formed into **pellets**

Recycled staple fibres and pellets are used as raw materials for new yarns and fabrics

PART 2

DESIGN TOOLBOX

This section provides guiding recommendations to improve the recyclability of **single-layer garments** for chemical recycling.

The toolbox **steps away from the mono-material approach** and provides some leniency in the usage of blends.

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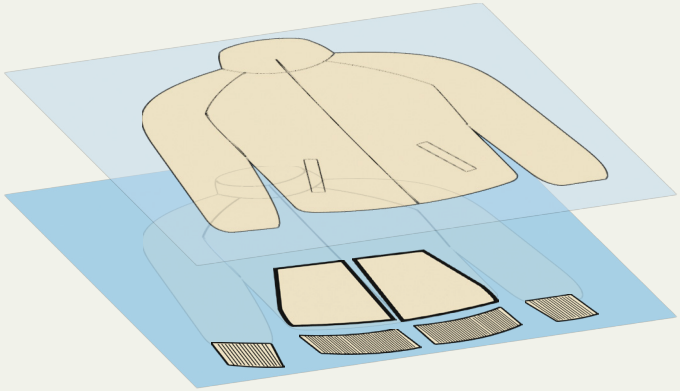
THINKING IN GARMENT LEVELS

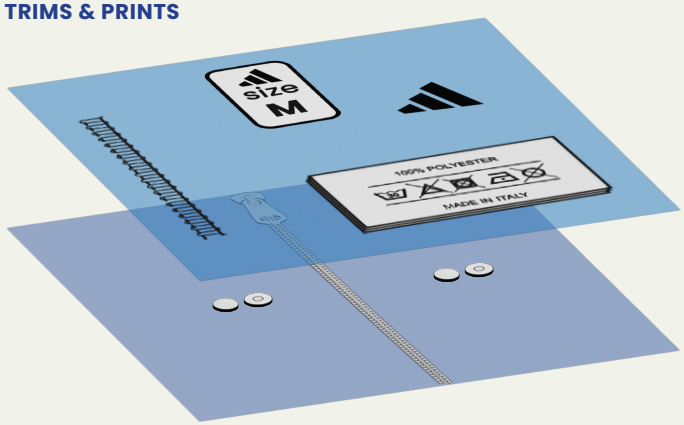
Garment design involves a lot of materials and product components that influence its overall functionality, durability and recyclability. Following the typical design process, we have identified **four key levels that form the basic structure of designing for recyclability**. The deliberate choices that are made in each of these areas will significantly impact the garment's recyclability, as this is the moment when its efficiency in sorting, pre-processing and recycling is determined.

The main fabric is the basis of a recyclable garment design: this is generally the part of the garment that will be recycled. The first and most important step is therefore to develop a main fabric with a recyclable composition. The other garment elements (secondary fabrics, prints, soft & hard trims) with a different composition to the main material are generally seen as contaminants because these need to be removed from the garment.

FABRICS



TRIMS & PRINTS



LEVEL 1: MAIN FABRIC

- The main fabric constitutes the largest component and main surface area of the garment
- Based on the main fabric, it is determined during sorting for recycling if a garment is suitable for a specific recycling technology

LEVEL 2: SECONDARY FABRICS

- Secondary fabrics are commonly used as small parts inside or outside the garment
- These fabrics are usually not detected during sorting for recycling

LEVEL 3: SOFT TRIMS AND PRINTS

- Soft trims and prints are supple and generally have a strong bond with the fabric
- These items are usually not detected during sorting and cannot be removed during de-trimming

LEVEL 4: HARD TRIMS

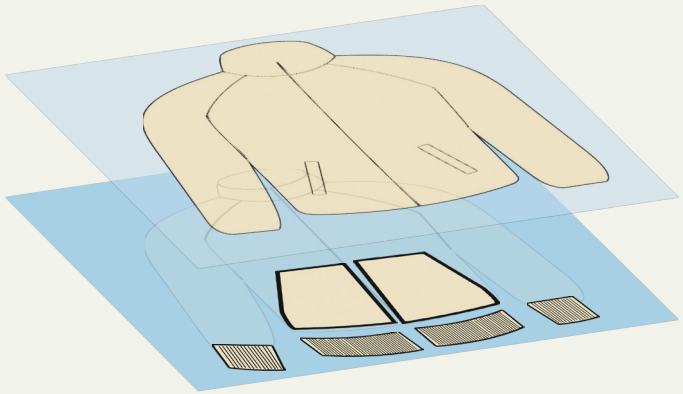
- Hard trims are solid and are generally heavier than the fabric
- These items can normally be removed during de-trimming

GENERAL GUIDANCE: FABRICS

Designing for recyclability starts with the fabric as this will generally be the feedstock for textile recycling. Focussing on the design and application of fabrics for their recyclability, **mono-material is always the preferred approach**.

Considering that we also want to design for demand and durability, **this guidance provides some leniency when it comes to the use of blends**. However, it is important to know that material blends are not without consequences since they result in waste and can significantly complicate recycling.

MAIN & SECONDARY FABRICS



MATERIAL COMPOSITION

Mono-materials are preferred. ✓

Recycled materials can be used as they can become feedstock for chemical recycling. ✓

Some **blends of two materials** can be detected in sorting and potentially be recycled, if material thresholds have been considered. !

Blends with elastic fibres are difficult to detect in sorting and can complicate recycling, so try to minimise their usage. !

Blends of three or more materials can often not be accurately detected in sorting and can cause contamination of feedstock, resulting in inefficient recycling. ✗

FABRIC DYES, PRINTS, FINISHES AND COATINGS

Material specific reactive, disperse and acid **dyes**, as well as fabric **allover prints**, can be used as they don't harm recycling. ✓

Finishes and coatings should only be used when they enhance the functionality and durabilty of the garment. Depending on the recycling technology, some finishes and coatings can be accepted, but others can significantly harm the process.* !

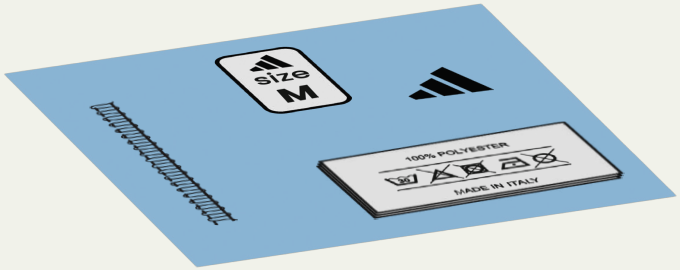
*Detailed research on the recyclability of finishes and coatings wasn't part of the scope of the T-REX project.

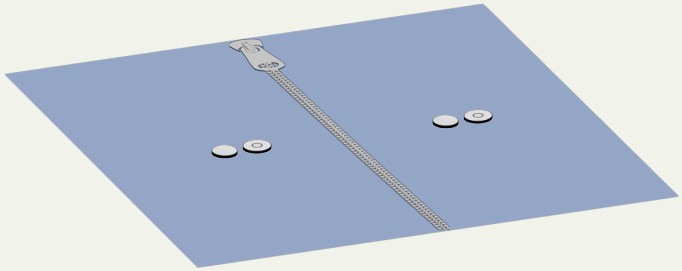
GENERAL GUIDANCE: TRIMS & PRINTS

Trims and prints are generally considered contaminants that can complicate recycling. Consequently, there are **two ways to deal with them**: they should either be removed from the fabric during de-trimming, or they can stay attached to the fabric but then shouldn't be harmful to the recycling process. Hard trims can more easily be removed during de-trimming because of their weight difference to the fabric. This is more difficult for soft trims and direct prints due to their similarity in weight and their strong bond with the fabric.

Therefore, our general advice is to **first focus on making soft trims and graphic prints compatible with the corresponding recycling technology**, and then to address the hard trims. However, the general rule applies that all trims and prints that don't match the material of the main fabric need to be removed. This can result in a significant increase of processing waste.

SOFT & HARD TRIMS





SOFT TRIMS

Examples of soft components:
Heat transfers, inner elastics, soft elastics, tapes, pipings, labels, bonding films, seam tapes, interlinings, hook & loop closures, drawcords, sewing threads, embroideries, foams

Soft trims with the **same material composition** as the main fabric (mono-material) are preferred. ✓

Depending on the recycling technology, some soft trims with a **different material composition** can still be handled in recycling. !

As **sewing thread**, **care**, **and size labels** are a small part of the garment weight, they can generally be made of their usual material. !

HARD TRIMS

Examples of hard components:
Zipper teeth, sliders and pullers, buttons, cord stoppers, snap buttons, rivets, eyelets, buckles, key rings, aglets

Hard trims will most likely be **removed during pre-processing** so they can also be made of a different material composition. ✓

GRAPHIC PRINTS

Additional embellishments in the form of direct prints

Depending on the recycling technology, **some graphic prints can be handled** in recycling. As these prints typically consist of a variety of different components that are not specified individually, it is complex to define their compatibility with recycling in more detail.* !

Keep graphic prints as small as possible to prevent them from jeopardising the garment's recyclability. !

*Detailed research on the recyclability of graphic prints wasn't part of the scope of the T-REX project.

TRAFFIC LIGHTS FOR MATERIAL RECYCLABILITY

When designing for recyclability, we need to carefully consider the specific materials used in a design. Each material component of a garment can be useful or harmful for recycling, and therefore impact whether the garment becomes a valuable feedstock for recycling. To structure the degree of recyclability of materials, we have created **a traffic light system that will be used as the guiding principle on the following pages**.

Each recycling technology specialises in recycling one specifc material, and can handle different contaminants. As a result, **it is technology-dependent which traffic light colour a material is labelled with**: for one technology, cotton may be green while for another it is yellow. In this guideline, the traffic light system is applied to company-specific recycling technologies tested within the T-REX project: **Infinited Fiber Company, BASF and CuRe Technology**, which recycle cotton, polyamide 6 and polyester, respectively.

BEST CASE

The material is recyclable and can become a new raw material for garments

COMPLEMENTARY

The material is recyclable and can become a new raw material for garments, but can only be accepted to a certain threshold

COMPATIBLE

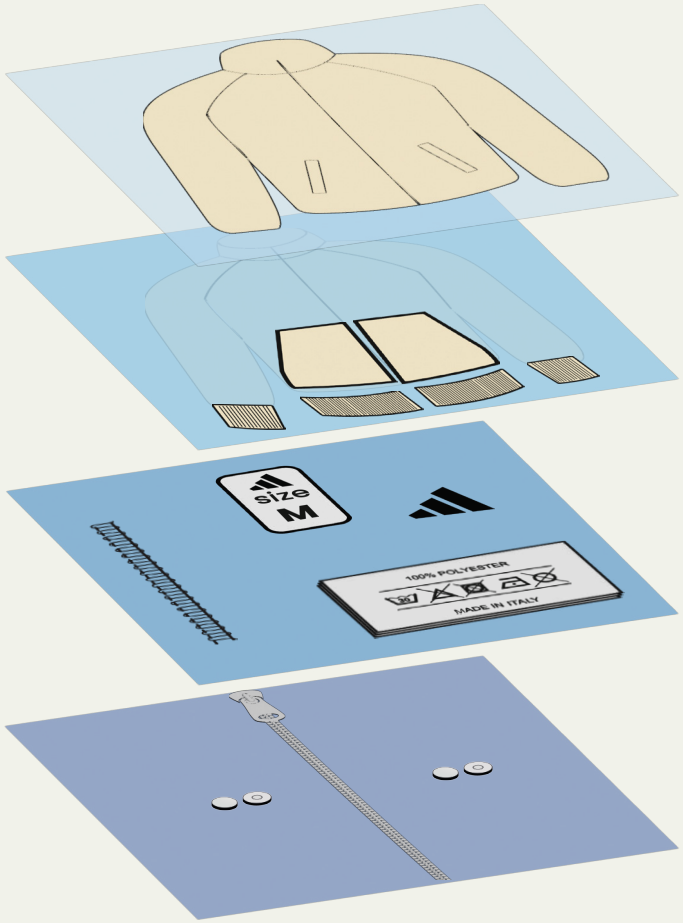
The material is accepted to a certain threshold, but it has a negative impact on the recycling process, its economics and environmental impact

DISRUPTER

The material is disruptive for recycling and makes the whole garment unrecyclable

TRAFFIC LIGHTS ON GARMENT LEVELS

Below is a **general methodology for how to apply the material traffic lights to the garment levels**. This principle applies to all recycling technologies, and is not material-specific. On the following pages, we illustrate how to apply this colour-coding system to cotton, polyester and polyamide 6 garments.



1. MAIN FABRIC

Select only 1 green material above the minimum threshold	
If a blend is required, add only 1 light green or 1 yellow material below the maximum threshold	

2. SECONDARY FABRIC

Preferably select green or light green materials	
Yellow materials can be selected, if below the maximum threshold	

3. SOFT TRIMS & PRINTS

Preferably select green or light green materials	
Yellow materials can be selected, if below the maximum threshold	

4. HARD TRIMS

Reduce the use of hard trims to minimise waste. All materials can be used because hard trims will be removed during de-trimming	

+ WEIGHT CALCULATION ON GARMENT LEVEL

The accumulated weight of all (light) green and yellow materials should adhere to their thresholds, and red materials should be removable or avoided	

COTTON RECYCLING: MATERIAL OVERVIEW

Infinited Fiber Company recycles textile waste by extracting cellulose from cotton-rich textiles, and regenerating them into high-quality man-made cellulosic fibres called Infinna™.

The table visualises the input materials that can be processed by Infinited Fiber Company. **The specified thresholds are related to the total weight of the material on a garment level.**

MATERIAL	MATERIAL LABELLING	WEIGHT THRESHOLD ON GARMENT LEVEL
Cotton	**CO**	**80–100%**
Man-made cellulosic fibres (MMCF) like viscose, cupro, modal, lyocell	**CV, CUP, CMD, CLY**	**0–20%**
Other cellulose fibres like linen, kapok, hemp, jute, alfa, coconut, ramie, sisal	**LI, CA, JU, AL, CC, RA, SI**	**0–5%**
Polyester	**PET, PBT, PTT, PLA**	**0–20%**
Elastane	**EL**	**0–5%**
Polyethylene	**PE**	**0–1%**
Polyamide / nylon (all types)	**PA**	**0–1%**
Polyacrylonitrile	**PAN**	**0–1%**
Polypropylene	**PP**	**0–1%**
Animal fibres (wool, silk, down)	**WO, SE, DOWN**	**0–1%**
Natural and synthetic rubber		**0–1%**
Thermoplastic polyurethane	**TPU**	**0–1%**
Thermoplastic elastomer	**TPE**	**0–1%**
Thermoplastic rubber	**TPR**	**0–1%**
Acrylonitrile butadiene styrene	**ABS**	**0–1%**

accumulated to **1%** max on garment level

MATERIAL	MATERIAL LABELLING	WEIGHT THRESHOLD ON GARMENT LEVEL
Cellulose acetate	**CA**	
Polyurethane	**PU**	
Silicone		
Polyoxymethylene (thermoplastic)	**POM**	
Acrylic polymer		
Ferreous and non-ferrous metal		
Glass particles (e.g. part of reflective heat transfers)		

Today, Infinited Fiber Company can incorporate 20% man-made cellulosic fibers (MMCFs) into the process. These fibres do not disrupt the operation, and produce similar high quality Infinna™ fibres as cotton feedstock. In the future, by adjusting process parameters, the feedstock can contain up to 100% MMCFs.

COTTON RECYCLING: GARMENT EXAMPLE

GENERAL TRAFFIC LIGHTS

1. MAIN FABRIC

Select only 1 green material above the minimum threshold	
If a blend is required, add only 1 light green or 1 yellow material below the maximum threshold	

2. SECONDARY FABRICS

Preferably select green or light green materials	
Yellow materials can be selected, if below the maximum threshold	

3. SOFT TRIMS & PRINTS

Preferably select a green or light green material	
Yellow material can be selected, if below the maximum threshold	

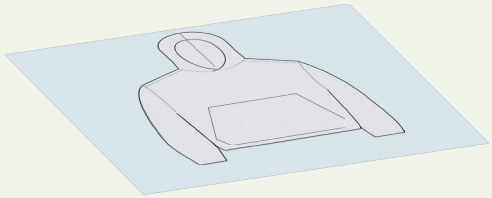
4. HARD TRIMS

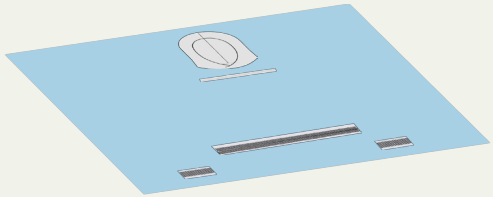
Reduce the use of hard trims to minimise waste. All materials can be used because hard trims will be removed during de-trimming	

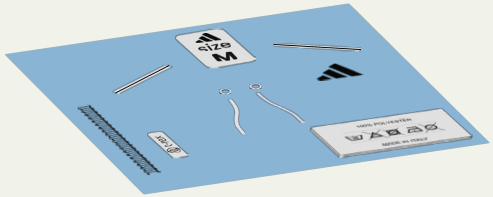
+ WEIGHT CALCULATION ON GARMENT LEVEL

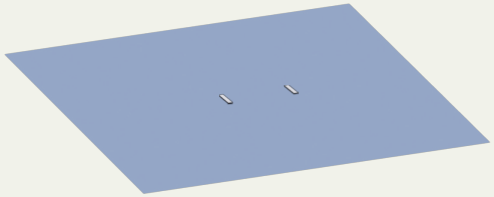
The accumulated weight of all (light) green and yellow materials should adhere to their thresholds, and red materials should be removable or avoided	

PRODUCT: HOODIE









POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
Body, sleeves, pocket & hood	100% CO	75,4%	We selected 100 % cotton because it suits the product purpose, while also being the most efficient for recycling.

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
Hood lining	100% CO	4,0%	For the hood lining and backneck tape we selected the same material composition as the main fabric. However, for the rib cuffs, this would reduce durability. As a result, elastane was added to keep the cuffs in shape.
Backneck tape	100% CO	1,0%	
Rib cuffs	95% CO	15,0%	
	5% EL	0,8%	

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
Drawcord	100% CO	1,7%	We selected trims from the existing library to utilise development & production resources efficiently. The use of these trims support the integration of designing for recyclability into standard product ranges. Since the yellow materials stay below the recommended thresholds, they won't harm recycling.
Size label + care label	100% PET	0,2%	
Sewing thread	100% PET	1,0%	
Logo + eyelet embroidery thread	100% PET	0,4%	
Interlining below embroidery	100% PET	0,2%	
Side flaglabel	100% PET	0,1%	
Shoulder tape	100% PET	0,1%	

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
Drawcord aglets	100% ACETATE	0,1%	Drawcord aglets add to the durability of a garment. We selected them from the existing library to utilise development & production resources efficiently. As the aglets can be removed, they can be made of a red material.

WEIGHT CALCULATION ON GARMENT LEVEL

97,1% CO	0,8% EL / 2,0% PET	0,1% (removable)

POLYESTER RECYCLING: MATERIAL OVERVIEW

CuRe Technology uses a low carbon footprint process to depolymerise polyester, purify it and then rebuild it into new raw materials.

The table visualises the input materials that can be processed by CuRe Technology.
The specified thresholds are related to the total weight of the material on a garment level.

MATERIAL	MATERIAL LABELLING	WEIGHT THRESHOLD ON GARMENT LEVEL
Polyester - polyethylene terephthalate	**PET**	**90-100%**
Polyester - polybutylene terephthalate	**PBT**	**0-10%**
Polyester - polytrimethylene terephthalate	**PTT**	**0-10%**
Polyethylene furanoate	**PEF**	**0-5%**
Elastane	**EL**	**0-5%**
Cotton	**CO**	**0-5%**
Polyamide / nylon (all types)	**PA**	**0-5%**
Polyethylene	**PE**	**0-10%**
Polypropylene	**PP**	**0-10%**
Polyurethane	**PU**	**0-5%**
Thermoplastic polyurethane	**TPU**	**0-5%**
Silicone		**0-10%**
Other cellulose fibres like linen, kapok, hemp, jute, alfa, coconut, ramie, sisal	**LI, CA, JU, AL, CC, RA, SI**	**0-5%**
Man-made cellulosic fibres (MMCF) like viscose, cupro, modal, lyocell	**CV, CUP, CMD, CLY**	**0-5%**
Ferrous and non-ferrous metal		**0-10%**
Glass particles (e.g. part of reflective heat transfers)		**0-5%**

MATERIAL	MATERIAL LABELLING	WEIGHT THRESHOLD ON GARMENT LEVEL
Polyacrylonitrile	**PAN**	
Polylactide	**PLA**	
Animal fibres (wool, silk, down)	**WO, SE, DOWN**	
Acrylonitrile butadiene styrene	**ABS**	
Polyoxymethylene (thermoplastic)	**POM**	
Natural and synthetic rubber		
Thermoplastic elastomer	**TPE**	
Thermoplastic rubber	**TPR**	
Acrylic polymer		

This table outlines the projected capabilities of CuRe Technology's commercial scale facility, which is in the planning phase. When suppling textile waste to the current CuRe Technology pilot facility, please check the latest recycler specifications.

CuRe Polyester Rejuvenation

POLYESTER RECYCLING: GARMENT EXAMPLE

GENERAL TRAFFIC LIGHTS

1. MAIN FABRIC

Select only 1 green material above the minimum threshold	
If a blend is required, add only 1 light green or 1 yellow material below the maximum threshold	

2. SECONDARY FABRICS

Preferably select green or light green materials	
Yellow materials can be selected, if below the maximum threshold	

3. SOFT TRIMS & PRINTS

Preferably select a green or light green material	
Yellow material can be selected, if below the maximum threshold	

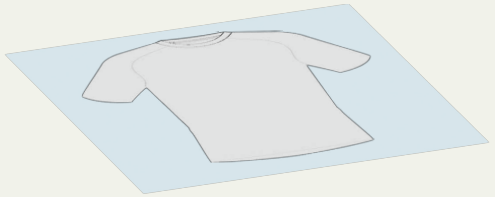
4. HARD TRIMS

Reduce the use of hard trims to minimise waste. All materials can be used because hard trims will be removed during de-trimming	

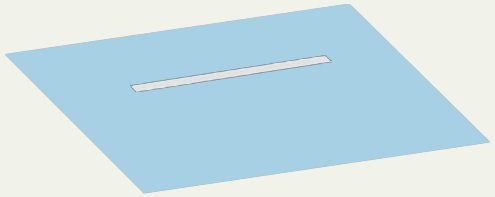
+ WEIGHT CALCULATION ON GARMENT LEVEL

The accumulated weight of all (light) green and yellow materials should adhere to their thresholds, and red materials should be removable or avoided	

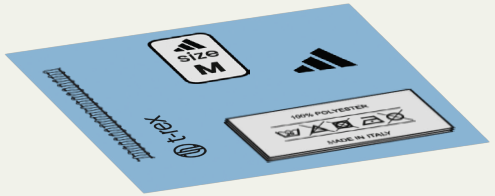
PRODUCT: FOOTBALL JERSEY



POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
Body, sleeves, collar	100% PET	96.8%	We selected 100 % polyester because it suits the product purpose, while also being the most efficient for recycling.



POSITION	% MATERIAL COMPOSITION	% GARMENT WEIGHT	RATIONALE
Backneck tape	100% PET	1,0%	The backneck tape could be made of the 100% polyester main fabric. This mono-material approach is always the best option for recycling.



POSITION	% OF MATERIAL COMPOSITION	% GARMENT WEIGHT	RATIONALE
Size label + care label	100% PET	0,5%	We selected trims from the existing library to utilise development & production resources efficiently. The use of these trims supports the integration of designing for recyclability into standard product ranges. Since the yellow materials stay below the recommended thresholds, they won't harm recycling.
Sewing thread	100% PET	1,5%	
Logo heat transfer I	100% PU	0,1%	
Logo heat transfer II	100% TPU	0,1%	

POSITION	% OF MATERIAL COMPOSITION	RATIONALE
N/A		There are no hard trims present in this garment.

WEIGHT CALCULATION ON GARMENT LEVEL

99,8% PET	0,1% PU 0,1% TPU	not applicable

POLYAMIDE 6 RECYCLING: MATERIAL OVERVIEW

BASF depolymerises polyamide 6 textile waste and converts it into a virgin-like material called loopamid®.

This table specifically addresses the recycling of polyamide 6 and visualises the input materials that can be processed by BASF. **The specified thresholds are related to the total weight of the material on a garment level.**

MATERIAL	MATERIAL LABELLING	WEIGHT THRESHOLD ON GARMENT LEVEL
Polyamide / nylon 6	**PA6**	**80–100%**
Polyamide / nylon 6.6 and all other types	**PA6.6, PA11**	**0–20%**
Polyester	**PET, PBT, PTT**	**0–20%**
Elastane	**EL**	**0–20%**
Polyethylene	**PE**	**0–20%**
Polypropylene	**PP**	**0–20%**
Polyacrylonitrile	**PAN**	**0–20%**
Polyurethane	**PU**	**0–20%**
Thermoplastic polyurethane	**TPU**	**0–20%**
Acrylic polymer		**0–20%**
Silicone		**0–20%**
Cellulose acetate	**CA**	**0–20%**
Acrylonitrile-butadiene-styrene	**ABS**	**0–20%**
Glass particles (e.g. part of reflective heat transfers)		**0–20%**
Natural and synthetic rubber		**0–5%**
Thermoplastic elastomer	**TPE**	**0–5%**
Thermoplastic rubber	**TPR**	**0–5%**
Cotton	**CO**	**0–5%**
Other cellulose fibres like linen, kapok, hemp, jute, alfa, coconut, ramie, sisal	**LI, CA, JU, AL, CC, RA, SI**	**0–5%**
Man-made cellulosic fibres (MMCF) like viscose, cupro, modal, lyocell	**CV, CUP, CMD, CLY**	**0–5%**
Animal fibres (wool, silk, down)	**WO, SE, DOWN**	**0–5%**

accumulated to **5%** max

MATERIAL	MATERIAL LABELLING	WEIGHT THRESHOLD ON GARMENT LEVEL
Polyoxymethylene (thermoplastic)	**POM**	
Ferrous and non-ferrous metal		

BASF can handle commonly used finishes and coatings on PA6 outerwear garments.

Polyamides always have a number (like polyamide 6 or 6.6), which refers to the chemical structure and corresponding properties of the polymer. From a recycling perspective, a distinction between the types of polyamides is required.

loopamid®
A BRAND OF BASF

POLYAMIDE 6 RECYCLING: GARMENT EXAMPLE

GENERAL TRAFFIC LIGHTS

1. MAIN FABRIC

Select only 1 green material above the minimum threshold	
If a blend is required, add only 1 light green or 1 yellow material below the maximum threshold	

2. SECONDARY FABRICS

Preferably select green or light green materials	
Yellow materials can be selected, if below the maximum threshold	

3. SOFT TRIMS & PRINTS

Preferably select a green or light green material	
Yellow material can be selected, if below the maximum threshold	

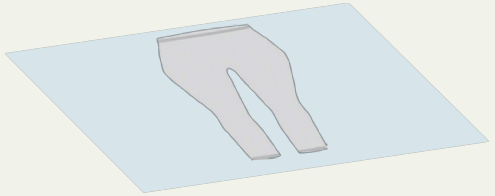
4. HARD TRIMS

Reduce the use of hard trims to minimise waste. All materials can be used because hard trims will be removed during de-trimming	

+ WEIGHT CALCULATION ON GARMENT LEVEL

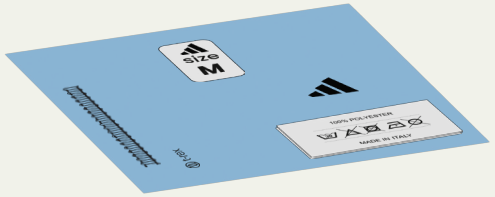
The accumulated weight of all (light) green and yellow materials should adhere to their thresholds, and red materials should be removable or avoided	

PRODUCT: LEGGINGS



POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
Body & legs	94% PAG	92,3%	A minimum of 6% elastane is needed for the main fabric to achieve the desired product purpose. However, as it stays below the recommended thresholds, it won't harm recycling.
	6% EL	5,9%	

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
N/A			There is no secondary fabric present in this garment.



POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
Size label + care label	100% PET	0,7%	We selected trims from the existing library to utilise development & production resources efficiently. The use of these trims supports the integration of designing for recyclability into standard product ranges. Since the yellow materials stay below the recommended thresholds, it won't harm recycling.
Sewing thread	100% PET	0,7%	
Logo heat transfer I	100% PU	0,2%	
Logo heat transfer II	100% TPU	0,2%	

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE
N/A			There are no hard trims present in this garment

WEIGHT CALCULATION ON GARMENT LEVEL

92.3% PAG	5.9% EL 1.4% PET 0.2% PU 0.2% TPU	not applicable

WRAPPING UP & LOOKING AHEAD

THIS TECHNICAL GUIDANCE IS AN IMPORTANT FIRST STEP

This T-REX Technical Guidance **shares detailed information from technical trials to guide designers and product developers in creating recyclable garments**. By stepping away from a complete mono-material approach, we intend to enable more flexibility when designing for recyclability. While we believe this guidance offers a valuable starting place, it is only the first step. Limitations to the scope of this document means that future research will be necessary to fill knowledge gaps.

As such, this Technical Guidance is intended as a report from a research project and should not be used for any commercial purposes. None of the involved research partners can be held liable for the guidance provided in this document.

WE CAN'T SOLVE IT ALL IN ONE TRY

The information in this Technical Guidance is based on results from the T-REX Project and the recycling technologies from Infinited Fiber Company, CuRe Technology and BASF. Since these **companies are in the process of scaling**, the material tables may change over time.

Additionally, **other recycling technologies on the market may have different feedstock specifications**. An industry-wide standard for recyclability should consider these technologies, and therefore, the specifications of such a standard may differ from the information provided in this document. Designers and material developers should stay informed about these industry-wide developments within textile-to-textile recycling.

FURTHER RESEARCH IS REQUIRED

Garments can be very complex, and not every aspect could be tested within the scope of the T-REX research project. **Further research** is needed to establish more detailed information on:

- The recyclability of a broad range of chemistry in **coatings, finishes and graphic prints**.
- The recyclability of **multi-layer garments**, as they add an extra level of complexity, both in the design as well as the sorting, pre-processing and recycling phase.

ALL STAKEHOLDERS NEED TO CONTRIBUTE

In the T-REX research project, we discovered that conversations between all stakeholders – brands, producers, sorters, pre-processors, recyclers and policy makers – are key for the textile recycling value chain to grow. **It's a shared responsibility to scale textile-to-textile recycling in Europe**, and it requires all stakeholders across the industry to commit to ensuring its success. Based on the learnings from developing this Technical Guidance, we particularly see potential in the following areas:

- Brands need to collaborate with their material suppliers **to make all material compositions available**, and to develop **weight calculation tools** to successfully apply the traffic light system on a garment level.
- Sorters and pre-processors are an indispensable part of textile-to-textile recycling value chain. **Investment is required** for these technologies to reach maturity, and for the supply chain to become economically viable.
- Ecodesign for Sustainable Products Regulation (ESPR) is essential in establishing **standardisation for recyclability**, for which this Technical Guidance can serve as a blueprint.

APPENDIX

t-rex

OVERVIEW OF SOFT TRIMS & PRINTS MATERIAL COMPOSITION

✕ = commonly used materials for the specified trim type

MATERIAL		Non-elastic tape, binding or piping	Elastic tape, binding or piping	Badge	(Flag) label	Interlining	Sewing thread	Embroidery thread	Heat transfer	Direct screen print	Non-elastic drawcord	Elastic drawcord	Hook & loop closure	Bonding tape/film	Seam sealing tape/film
Polyester - polyethylene terephthalate	**PET**	✕	✕	✕	✕	✕	✕	✕	✕		✕	✕	✕	✕	✕
Polyester - polybutylene terephthalate	**PBT**			✕											
Polyamide 6 / nylon 6	**PA6**	✕	✕	✕	✕	✕	✕				✕	✕	✕	✕	✕
Polyamide / nylon others	**PA OTHERS**	✕	✕	✕			✕						✕	✕	✕
Cotton	**CO**	✕	✕		✕	✕	✕	✕			✕				
Elastane	**EL**		✕									✕			
Viscose	**CV**					✕		✕		✕					
Polypropylene	**PP**	✕				✕					✕				
Polyethylene	**PE**														
Polyurethane	**PU**		✕	✕	✕	✕			✕	✕		✕		✕	✕
Rubber			✕						✕			✕			
Silicone			✕	✕	✕				✕	✕					
Acrylic polymer										✕					
Thermoplastic rubber	**TPR**								✕						
Thermoplastic elastomer	**TPE**					✕								✕	
Thermoplastic polyurethane	**TPU**			✕					✕				✕	✕	
Glass particles			✕	✕	✕				✕	✕					
Aluminium			✕	✕	✕				✕	✕					

OVERVIEW OF HARD TRIMS MATERIAL COMPOSITION

✕ = commonly used materials for the specified trim type

MATERIAL		Button	Snap button	Cord stopper	Aglet	Metal zip	Coil zip	Vislon zip	Puller	Hook & eye	Ring, buckle	Rivet
Polyester - polyethylene terephthalate	**PET**	✕	✕	✕	✕	✕	✕	✕	✕			
Polyester - polybutylene terephthalate	**PBT**	✕						✕				
Polyamide 6 / nylon 6	**PA6**	✕		✕					✕	✕	✕	
Polyamide / nylon others	**PA OTHERS**							✕	✕			
Cellulose acetate	**AC**				✕							
Polypropylene	**PP**			✕								
Polyethylene	**PE**								✕			
Polyurethane	**PU**				✕				✕			
Rubber									✕			
Silicone				✕	✕		✕		✕			
Thermoplastic rubber	**TPR**								✕			
Thermoplastic elastomer	**TPE**	✕		✕					✕			
Thermoplastic polyurethane	**TPU**	✕	✕	✕	✕	✕	✕	✕	✕		✕	
Acrylonitrile butadiene styrene	**ABS**	✕		✕	✕						✕	
Polyoxymethylene	**POM**		✕	✕			✕	✕	✕	✕	✕	
Glass beads (reflectives)										✕		
Aluminium					✕	✕				✕	✕	✕
Brass		✕	✕	✕	✕	✕		✕	✕	✕	✕	✕
Zinc alloy		✕	✕	✕	✕	✕	✕	✕	✕	✕	✕	✕
Stainless steel				✕				✕			✕	
Copper					✕	✕			✕			

GARMENT EXAMPLE PAGE

GENERAL TRAFFIC LIGHTS

1. MAIN FABRIC

Select only 1 green material above the minimum threshold

If a blend is required, add only 1 light green or 1 yellow material below the maximum threshold

2. SECONDARY FABRICS

Preferably select green or light green materials

Yellow materials can be selected, if below the maximum threshold

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4. HARD TRIMS

Reduce the use of hard trims to minimise waste. All materials can be used because hard trims will be removed during de-trimming

+ WEIGHT CALCULATION ON GARMENT LEVEL

The accumulated weight of all (light) green and yellow materials should adhere to their thresholds, and red materials should be removable or avoided

PRODUCT:

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE

POSITION	MATERIAL COMPOSITION	WEIGHT SHARE ON GARMENT LEVEL	RATIONALE

WEIGHT CALCULATION ON GARMENT LEVEL

GLOSSARY

TERM	DEFINITION
Agglomerating	In the context of textile recycling, it refers to the process of thermo-mechanically clustering shredded textiles and fibres into cohesive pellets. This is often done to improve the handling, storage, transportation, and recycling of textiles.
Chemical recycling	Manufacturing processes that convert waste materials into a feedstock by changing their chemical structure to be used in the production of new polymers, monomers, intermediaries, or other materials (CEN, 2023).
Circularity	Practices that optimise resource use and minimise waste across the entire production and consumption cycle, emphasising sustainability and economic efficiency (McKinsey & Company, 2024).
Compacting	In the context of textile recycling, it refers to the process of mechanically compressing shredded textile pieces into dense, manageable grains. This process is essential for efficient storage, transportation, and recycling of textiles.
Contaminant	In the context of the T-REX Project, a contaminant is perceived as a substance or material that can complicate the recycling of the product (adapted from CEN, 2023).
De-trimming	Activities by which trims are removed from the garments in order to prevent problems in the recycling process. It is often done manually, but automated techniques are being developed. De-trimming can result in significant material loss.
Disrupter	In the context of the T-REX Project, a disrupter is an element of a garment that degrades the quality of the recycling feedstock and prevents the recyclability of the garment.
Feedstock	A general term for the raw materials used as input for recycling processes (FFG, 2022).
Fiberising	After shredding, the fragmented textile pieces are further broken down into individual fibres.
Grinding	After shredding, the fragmented textile pieces are further ground into even smaller fibres or particles.
Hard trims	Trims containing solid components, which can be removed during de-trimming because of their weight difference from the fabric.

TERM	DEFINITION
Mechanical recycling	The process by which textiles are cut, shredded and opened into fibres that are usable for diverse applications such as insulation, filling or non-woven for automotive and other industries as well as textile-to-textile applications (adapted from FFG, 2022).
Mono-material approach	A garment design strategy that utilises fabrics and other components made exclusively from a single type of chemical composition.
Non-reusable clothing	Clothing that cannot be reused in its original form.
Post-consumer textile waste	Textile products generated by the end-users that can no longer serve their intended purpose, leading them to be discarded (adapted from CEN, 2023).
Pre-processing	All steps that sorted non-reusable clothing goes through before recycling. The steps can include cutting, shredding, de-trimming, fiberising, grinding, compacting and agglomeration, but they vary depending on the recycling stream and recycler's requirements.
Recyclability	In the context of the T-REX Project, this refers to textile-to-textile recycling. Non-reusable clothing should fulfill the ability to be collected, sorted and pre-processed into defined streams for recycling. The materials can be recovered and become a raw material for garment production.
Shredding	Activity where textiles are fragmented into smaller pieces to facilitate further processing. The size of these textile pieces can vary depending on the specifications of the recycling technology.
Soft trims	Trims containing flexible components that are difficult to remove due to their similarity in weight and their strong bond with the fabric.
Textile-to-textile recycling	In the context of the T-REX Project this refers to a process where collected non-reusable household textiles are sorted and pre-processed into defined streams for recycling. The materials can be recovered and become a raw material for textiles that are used in garment production.
Threshold	In the context of textile recycling, this refers to a specific limit or percentage value that must be met or not exceeded for certain materials or contaminants. These thresholds are important for ensuring the quality and efficiency of the recycling process.

RESOURCES

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FURTHER READING LEGISLATION

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Infinited Fiber Company: https://infinitedfiber.com
CuRe Technology: https://curetechnology.com
Loopamid by BASF: https://www.loopamid.com/global/en

For more information on the **T-REX Project**, please visit:
https://trexproject.eu

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