CISUFLO

CIRCULAR SUSTAINABLE FLOOR COVERINGS

D1.7 **Best practice guidelines**

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The Consortium: a well-balanced EU mix of manufacturers, RTOs and associations

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CISUFLO
CIRCULAR SUSTAINABLE FLOOR COVERINGS

Goal

Redesigning of flooring products so that they are fit for a circular economy.
3 types of flooring products:

1. Laminate,
2. PA6 carpet
3. Vinyl flooring.

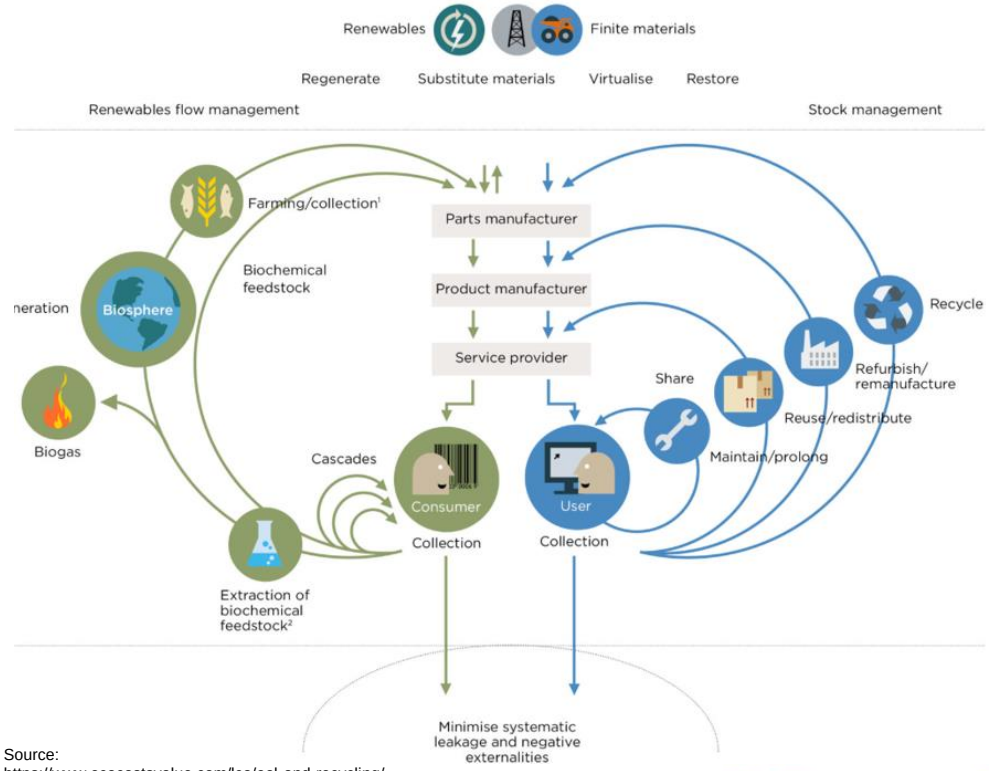
3 guiding levels:

1. Design for circularity,
2. Material selection
3. Manufacturing technology

Best practice guidelines for circular floor coverings.

- ePRODIS, online product information system, to integrate tags in all types of flooring products.

Circular economy



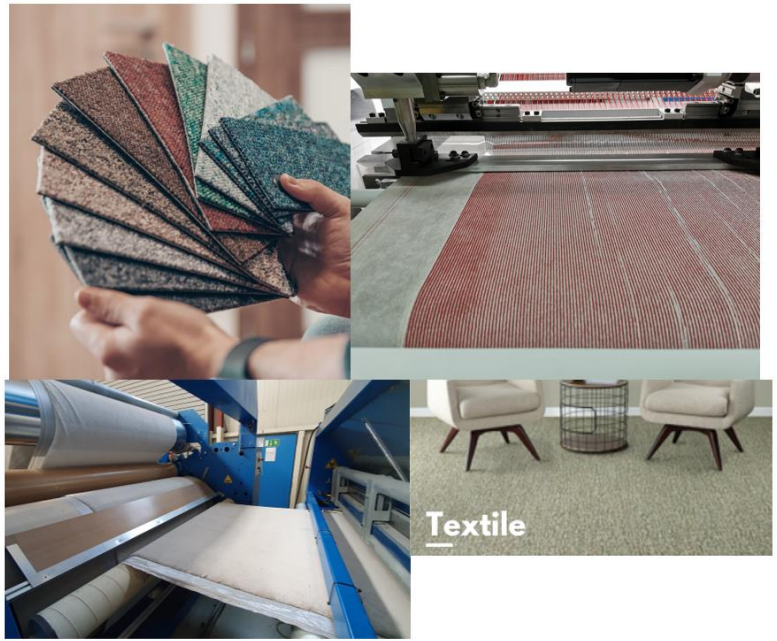
Source:
https://www.ecocostsvalue.com/lca/eol-and-recycling/

Points to consider **before** recycling

- Prolonged use phase
- Reusing/redistributing
- Refurbishment/remanufacturing

CTextile Guidelines

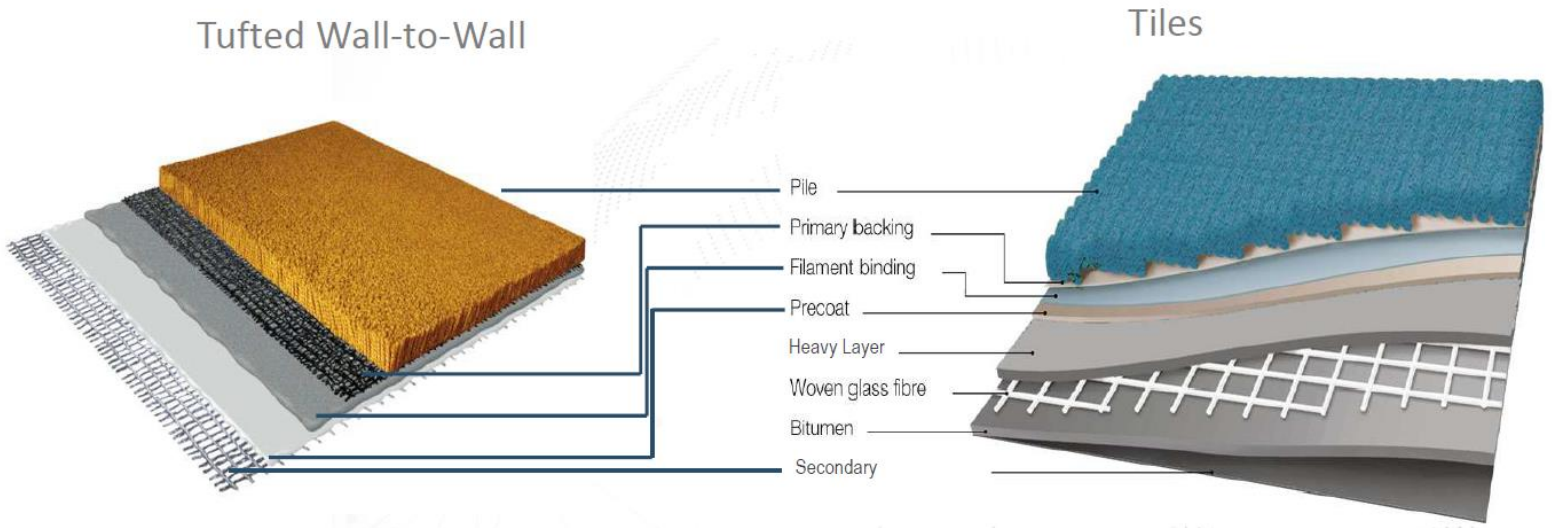
- Design
- Material
- Manufacturing
- Installation
- Tagging
- Recycling



CTextile State of the art

Classic construction principles of broadloom carpets and tiles

- Complex material mix, latex often used for filament binding and precoat

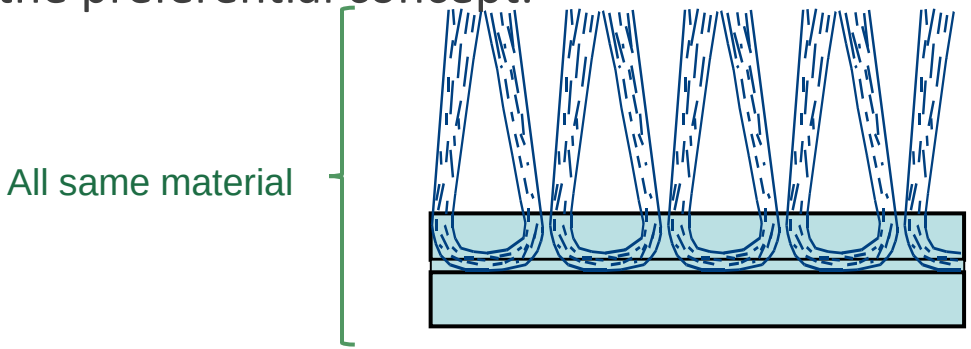


CTextile Design

There a two general concepts to design a carpet with a high circularity:

- Concept A: Monomaterial

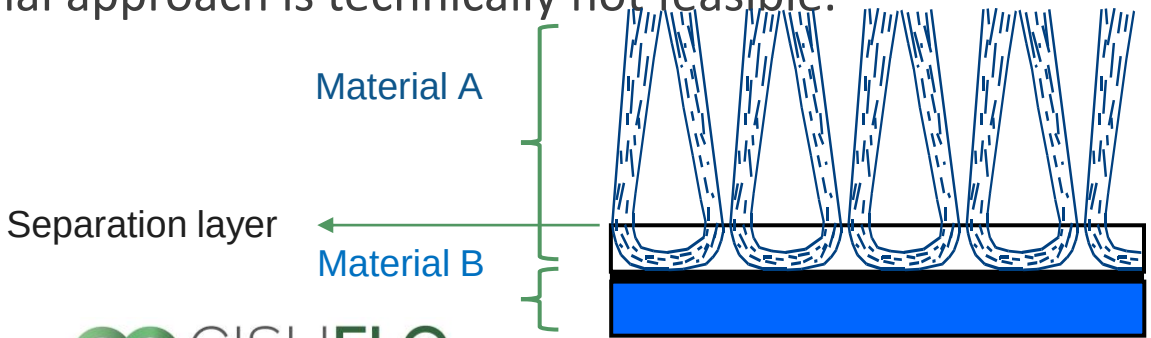
All layers of the carpet consist to a high degree from the same polymer. A certain degree of contamination can be tolerated (dependent on the recycling processes).
This monomaterial concept is the preferential concept.



CTextile Design

- Concept B: Separation layer

If the pile layer and secondary backing consist of different polymers
→ components can be connected by a special layer e.g. using hotmelt glues
→ providing the required properties during lifetime
→ this special layer can be triggered at end-of-life (via heat, solvent etc.) enabling separation of the layers, allowing to deliver them to separate recycling routes
→ Used when a monomaterial approach is technically not feasible.



CTextile Design

- Influence parameters on the design:
  - Realization of the pile fixation: fusion bonding, glue layer
  - Composition of the layers
  - Mass balance of the polymer shares of the structure
  - Use of latex for pile fixation or lamination
    - Should generally be avoided
    - Could also have a function as a separation layer if used in a very brittle version which could be mechanically removed before the material recycling
- For tiles and rubber mats separation concept applicable

CTextile Material

- Focus on PA6 carpets due to
  - Market significance for Europe
  - General recycling capability of PA6
  - Availability of recycled PA6 carpet yarns from among other fisher nets (Econyl)

- Primary backings from PA6 are not available due to insufficient stability and humidity resistance
  → Use of standard PP and PES backings (accepted as impurity during recycling)
- Big variety of hotmelt glues based on CoPA, PP, PE, PB available
  - Chips, powder, nonwovens, foils
  - Different melting points, viscosities, process suitability
  - Promising results for the PB glue → stability, separation

CTextile Material

- Secondary backing: Focus on nonwovens due to availability, but also woven fabrics possible
  - For monomaterial: backing with high PA ratio required
  - For separation: different materials possible, more flexible construction possible
  - All variants processible with different types of hotmelt glue

CTextile Manufacturing

- Circularity approach has no influence on tufting process and vice versa

- Fixation of piles: Heat calender for fusion bonding without glue (PES primary), heat calender with powder scattering device for application of glue (PP primary)

- Lamination of secondary backing depends on glue condition
  - Heat calender with powder scattering device for powder glues (tested)
  - Heat calender with additional infrared heater for pre-impregnating surfaces (not yet tested)
  - Heat calender with extrusion device for glues in chip form (not yet tested)
  - Heat calender with special guiding for two-side glue foils (not yet tested)

CTextile Installation

Consideration for the following scenarios:

- → Innovative: can be dismantled without leaving any residue and without causing any damage
- → Conventional: Residue-free and non-destructive dismantling is usually not possible

CTextile Installation

- Goal: To remove the textile floor covering in large pieces without leaving any residue and without destroying it.
- Impact on tagging: Residue-free and non-destructive removal allows a low number of tags on the floor covering.
- The following installation methods are to be used for this type of installation:
  - Loose layed (if feasible)
  - Installation tapes with 3D structure e.g. Microplast Tape
  - Liquid dispersion fixation - water-based tackifier
  - For textile tiles, padges can be used for fixing (e.g. Avery Dennison FT4361).

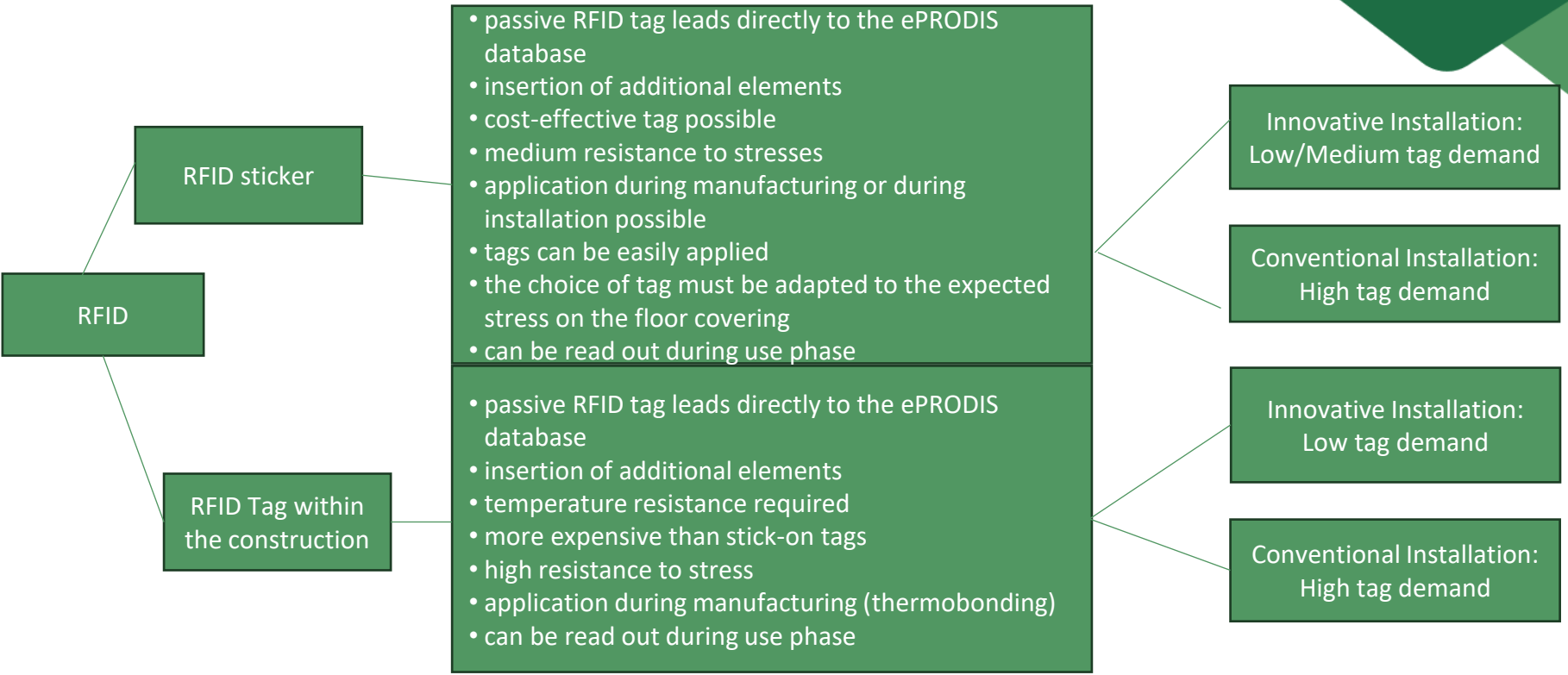
CTextile Tagging

Goal: To make information about the entire useful life accessible:

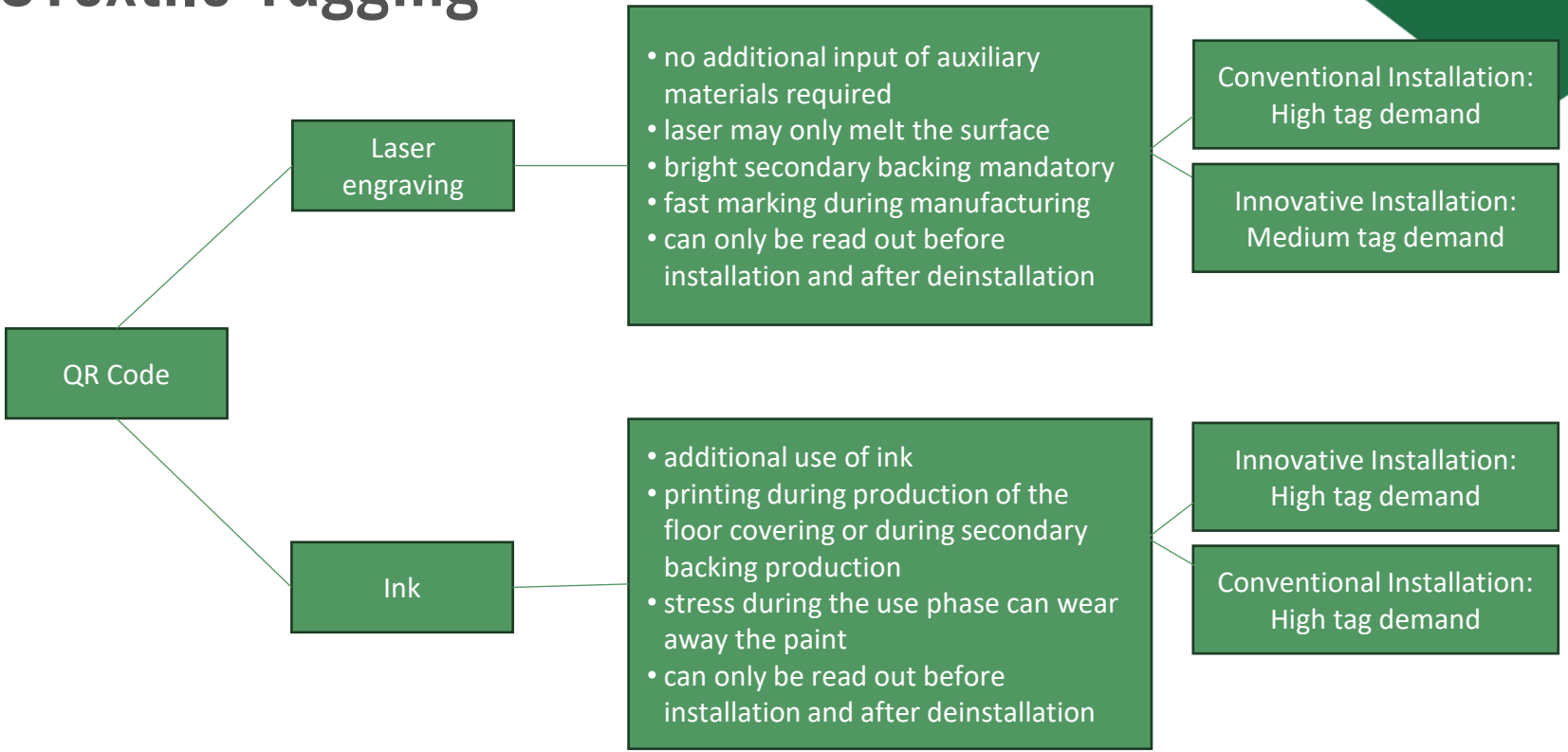
- Information on the installation and recommendations for deinstallation
- Composition of the materials and ingredients
- Possible recycling routes
- Information for the use phase etc.

Challenge: Find a suitable interface between the textile floor covering and the technical data and required information on ePRODIS.

CTextile Tagging



CTextile Tagging



CTextile Tagging

- There is no tagging method which fulfills all requirements regarding durability, readability, implementation effort and costs
  - The choice of the tagging system is a compromise keeping the abovementioned criteria in mind
- A uniform approach is needed, and the framework conditions need to be defined by standardisation.

CTextile Recycling

- The chemical recycling of monomaterials tolerates some amount of contamination. General rules of thumb for PA6 carpets:
  - PES/PET contamination < 7 %
  - Amount of PA6 > 80 %
  - Polyolefin contamination not so critical compared to PES/PET contamination

- Layer separation, when using a hotmelt layer, in heated condition proven at hotmelt calender
  - Up to now only manual separation, automatic solution required
  - Use of click-glues promising (separation after heat treatment in cool condition)
- Proof of circularity ongoing

Transferability to PET/ PP carpets

- CTextile Design:
  The approach is similar to PA6 carpets: both the monomaterial and the separation layer concept are applicable.
  The monomaterial approach is also preferential for PET or PP carpets.

- CTextile Material:
  - PP and PET primary backings are commonly used.
  - Latex replacement: PO and coPET waterborne dispersions are available on the market, as hotmelt glues based on PO and coPET.
  - Secondary backings: PP and PET (non)wovens are available.

Transferability to PET/ PP carpets

- CTextile Manufacturing:

- Fusionbonding of PP/PET piles into the corresponding PP/PET primary backing is challenging, and needs a very narrow processing window, not to simultaneously melt the backing. Hence, this technique is less recommended.

- Pile fixation and lamination of a secondary backing using hotmelt glues is feasible for a PET or PP carpet.

- Waterborne PO or coPET dispersions can be applied using the commonly used knife coating process (similar as for latex dispersions)

Transferability to PET/ PP carpets

- CTextile Installation: the same guidelines are applicable.
- CTextile Tagging: the findings for tagging can be transferred to PET and PP carpets.
- CTextile Recycling:
  - Contamination levels acceptable during the recycling process (PET: chemical or thermo-mechanical, PP: thermo-mechanical (or pyrolysis)) are dependent on the selected recycling process, and so will differ for both PET and PP carpets.
  - Using a hotmelt layer to separate a PP carpet will be difficult due to the lower melting point of PP. A separation layer based on solvent triggering could be more suited.

CLaminate Guidelines

- Design
- Material
- Manufacturing
- Installation
- Tagging
- Recycling

CLaminate Design

- Laminate flooring according to EN 13329 consist of:
  - A fibreboard substrate (HDF)
  - On top a decorative surface and a surface wear layer
  - At the backside a balance layer
  - Top and balance layers are made from paper which are impregnated with aminoplastic thermosetting resins.

- Designed for floating installation, laminates are easy to install. The recyclability of the material depends on its easy deinstallation and removal.

CLaminate Material

- Laminates as currently produced have good recyclability potential
- Laminates are made up of 85% fibreboard (HDF) composed of fibres glued to the core of the material covered with impregnated decorative papers.
  - For HDF, the type of glue used in the manufacture of the panel can influence its recyclability.
  - Recommendation: Use a glue containing less than 12% melamine for UF or MUF adhesives
  - Fibre glues made from pMDi and PF type glues are more difficult to separate
  - Reduce the part of impregnated decorative papers.

CLaminate Manufacturing

- Laminates offer a process that is already eco-friendly
  - No banned chemicals used, even on the oldest products on the market
  - Consistent composition from one manufacturer to another
  - The floating installation allows easy dismantling for repair and end-of-life purposes

- The use of bioglues in the manufacture of HDFs could be a plus in terms of the product's eco-compatibility and recyclability.
  - But still waiting for mature solution

CLaminate Installation

- In most cases, laminate flooring is laid as a floating floor.
  This type of recommended installation avoids the need to add glue during installation. This allows easy removal.

- Recommendations
  - Promote the use of 'click' systems to avoid the need for any additional fixing
  - Or Use of metal clips that can be easily removed and separated for recycling.
  - Avoid the use of plastic inserts
  - Avoid the use of attached underlays, to facilitate separation of materials
  - Or prefer the use of attached wood fiber based underlays which could be recycled with the HDF without preliminary separation.

CLaminate Tagging

- Objective: To provide information about the entire life course accessible:
  - Information on the installation and recommendation for deinstallation
  - Composition of the materials and ingredients
  - Information for the use phase and maintenance
  - Possible access points for collection and recycling routes at end of life

- Currently: numeric code printed on laminate elements identifying process

- Challenge: to make all the information available concerning the process and the origins of the materials used, to provide the necessary information in ePRODIS

CLaminate Tagging

- QR Code
  - Solution identified as the easiest to implement.
  - Off-line printing every 10 cm is recommended (25 to 100 codes per m^2). This would make it possible to read the panels during recycling, even when they are cut out.

- RFID
  - RFID tags can be affixed, but the process is currently too expensive
  - Problem of tag durability during pressing at high temperatures: 200°C
  - Risk of contamination if glue is added to fix the tag in place after pressing

CLaminate Recycling

- Laminates can be destructured to recover the fibres and produce new materials.
  - The body of the panel can easily be used to produce new fibres
    - Steam explosion process studied showing 100% fibre recovery
    - Fibres can be used to produce new panels (MDF, HDF)
  - Separation of impregnated decorative papers: can be burnt (source of energy)
    - Recycle certain compounds (such as alumina oxides from ashes).
- To achieve effective recycling of laminate waste, wood waste separation must be optimised and harmonised to ensure its recycled as fibres and not used for energy recovery.

CVinyl Guidelines

- Design
- Material
- Manufacturing
- Installation
- Tagging
- Recycling

Cushion Vinyl: Material

2 possibilities to reduce the environmental footprint of Cushion Vinyl made with the plastisol coating process:

1. Exchanging materials made from fossil fuels by materials made from recycled or renewable sources with the same properties

   →Biobased plasticizer or PVC made from circular feedstocks

   →Mass balance approach

2. Introduce post-industrial/post-consumer recycled cushion vinyl powder
   - Particle size of the powder needs to be small enough i.e. maximum 300 – 400 µm
   - The inclusion of recycled cushion vinyl powder has its limits: maximum 3 – 5 wt. % of recycled content is possible

Cushion Vinyl: Manufacturing

2 possibilities to manufacture sustainable cushion vinyl

1. Plastisol coating technology
   - Exchange current materials with their recycled (made from circular feedstocks) or biobased counterparts

     → Currently a limited capacity to produce these materials

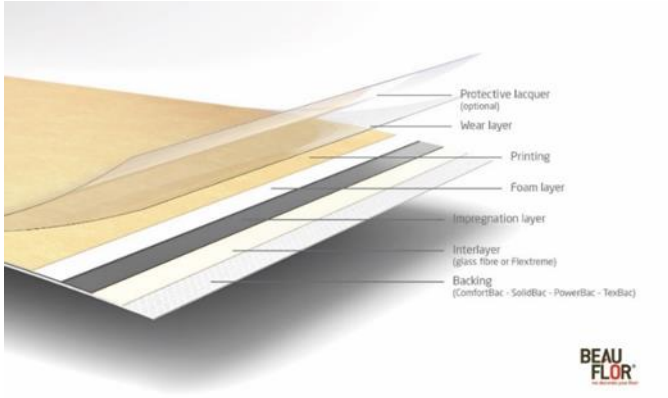
     → More expensive than virgin materials due to the limited capacity

   - Include recycled cushion vinyl powder in the product

     → Maximum particle size of the powder is 300-400 µm

     → Limitation on amount of recycled content to 3-5 wt%

2. Extrusion or double-belt press technologies
   - High amount of recycled content possible



Cushion Vinyl: Design for circularity

- Cushion vinyl flooring can be covered at the back with a textile needle felt
  - The back felt layer is hampering the recycling of cushion vinyl at end-of-life
- Redesign of textile backed cushion vinyl products is necessary to create a sustainable cushion vinyl floorcovering
  - Possible solutions
    - Monomaterial product → use a PVC-based textile backing
    - Separation layer
      - Use of hotmelt glues as a separation layer
      - Different types of hotmelts can be used: coPES, coPA, …

Cushion Vinyl: Installation

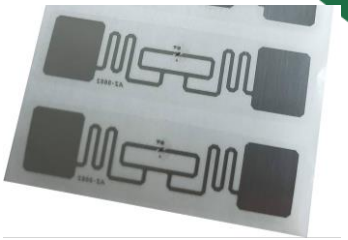
- Currently, cushion vinyl products are mainly glued to the subfloor at installation
  - End-of-life: pieces of the subfloor will remain attached to the cushion vinyl when de-installed
    → Increases complexity and cost of recycling post-consumer cushion vinyl
- Loose-layed cushion vinyl as a solution for cleaner waste streams
  - Different methods of loose-lay methods exist
    - No glue is used. This is the simplest solution, but this means that the product should be floating installed and thus be dimensionally stable and have a suitable density
    - Pressure sensitive adhesives can be used to fixate a cushion vinyl floor. These adhesives have a low peel strength and a high shear strength
    - Single- or double-sided tapes can also be used on edges of the room or at seams

Cushion Vinyl: Tagging

- *Goal*: To make information about the entire life course accessible:
    - Information on the installation and recommendation for deinstallation
    - Composition of the materials and ingredients
    - Information for the use phase and maintenance
    - Possible access points for collection and recycling routes at end of life

- *Challenge*: Find a suitable interface between the cushion vinyl floor covering and the technical data and necessary information on ePRODIS.

Cushion Vinyl: Tagging



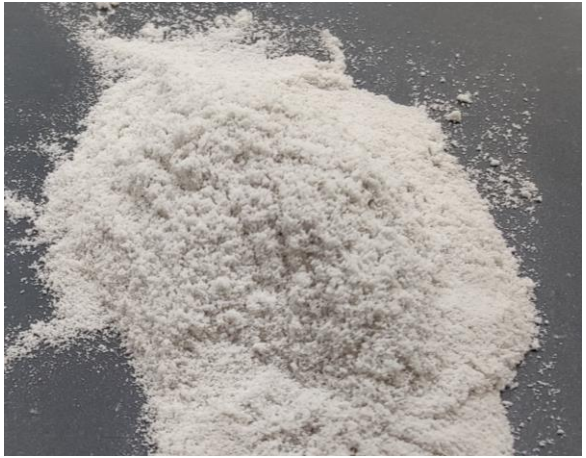
Possible interfaces for tagging:

- RFID tag:
  - RFID sticker on the backside is not possible due to the fact that the main installation method is gluing

  → This can be an option if all cushion vinyl can be installed loose-layed
  - RFID tag incorporated in the product need to withstand temperatures of up to 200 °C
    - Technological challenge: heat-resistant tags have a significant thickness (± 0,5 mm)
    - Economical challenge: 2€/tag is not possible
- QR-code/watermarking
  - Incorporated in the printing design using digital printing

Cushion Vinyl: Recycling

- Post-industrial and post-installation waste can be recycled via mechanical recycling into pellets, flakes or powder



Cushion Vinyl: Recycling

- Post-consumer waste streams recycling is challenging due to the presence of legacy additives
  - Separation between REACH and non-REACH compliant waste streams is necessary
    - REACH compliant waste streams can be mechanically recycled
    - Non-REACH compliant waste streams need more advanced recycling techniques to extract and separate the legacy additives from the waste stream

    Examples of advanced recycling technologies

    → Solution-dissolution technology

    → Chemical recycling

Cushion Vinyl: Recycling

- Recycling of textile backed cushion vinyl
  - Monomaterial products can be easily recycled as no separation is needed
  - The use of a separation layer for textile backings made from other polymers will improve the recycling
  - Without a separation layer, other technologies can be used:
    - Mechanical grinding followed by air-separation
    - Separation via solution-dissolution technology
    - Chemical recycling

Luxury Vinyl Tiles: Design, material & manufacturing

- Luxury vinyl tiles (LVT) can already include a high amount of recycled content (up to 100 wt%) in the extruded base board
- The recycled content can come from different sources:
  - Window frames
  - PVC pipes
  - Other rigid PVC sources without plasticizers
- The recycled content can be added in the form of pellets, regrind or powder

.

Luxury Vinyl Tiles: Design, material & manufacturing

- Caution is advised when using post-consumer waste streams as this can contain lead
  - Pb-concentration in the final product needs to be < 0.1 wt%

- LVT products with an underlay already attached need to be redesigned for recycling:
  - Monomaterial product → subfloor made from PVC
  - Separation layer should be added when the subfloor is made from another polymer

Luxury Vinyl tiles: Installation

- Luxury vinyl tiles can already be installed as loose-lay, this gives an advantage of a clean waste stream for recycling when the floor is deinstalled

Luxury Vinyl tiles: Tagging

- *Goal*: To make information about the entire life course accessible:
  - Information on the installation and recommendation for deinstallation
  - Composition of the materials and ingredients
  - Information for the use phase and maintenance
  - Possible access points for collection and recycling routes at end of life

- *Challenge*: Find a suitable interface between the cushion vinyl floor covering and the technical data and necessary information on ePRODIS.

- Several tagging options for LVT are available, due to its loose-layed installation:
  - A QR-code can be printed, stickered or engraved on the backside of the board
  - RFID tags can be glued to the backside
  - QR-codes or watermarkings can be included in the printing design

Luxury Vinyl tiles: Recycling

- The preferred option for recycling LVT is mechanical recycling
- Awareness of legacy additives is crucial when using post-consumer waste streams (e.g. Pb content)
  - An extraction of non-REACH compliant additives from post-consumer waste streams of LVT will be necessary
    - Solution-dissolution or chemical recycling can be used to provide clean recycled waste streams

Abbreviations

- **CISUFLO** Circular Sustainable Floorings
- **CoPA** Copolyamide
- **CoPET** Copolyethylene terephthalate
- **CV** Cushion Vinyl
- **ePRODIS** Electronic product information system
- **HDF** High-density fiberboard
- **LVT** Luxury Vinyl Tiles
- **MDF** Medium-density fiberboard
- **MUF** Melamine urea-formaldehyde
- **PA6** Polyamide 6
- **PB** Polybutene
- **PES** Polyester
- **PET** Polyethylene terephthalate
- **pMDi** Polymeric methyl diphenyl diisocyanate
- **PO** Polyolefine
- **PP** Polypropylene
- **PVC** Polyvinylchloride
- **REACH** Registration, Evaluation, Authorisation and Restriction of Chemicals
- **RFID** Radio Frequency Identification
- **UF** Urea-formaldehyde
- **QR** Quick response
- **WP** Work package

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The guidelines provided in this document are the result of the work carried out in the CISUFLO project, which focusses on PA6 textile floor covering, laminate flooring and cushion vinyl and luxury vinyl tiles. Hence, this list of guidelines is non-exhaustive.

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