Verification and examination of recyclability

Requirements and assessment catalogue

of the Institute cyclos-HTP

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</table>
1. Assessment Framework and Methodology

Recycling is an important factor for the sustainable utilisation of resources. Recyclability can be determined for different packaging types and goods as an individual attribute and, in the form of a gradual index, an expression and instrument of applied product reliability.

Recyclability is generally defined by two parameters: the composition of the object and the real recycling options after usage.

The examination of recyclability must provide objective information about the status of recycling capability of packaging and goods. Moreover, it can supply additional important information on the optimisation of packaging and goods. In order to do this, scientifically-validated, comprehensible and for all stakeholders transparent requirements and assessment criteria have to be established.

For this reason, Institute cyclos-HTP has applied its expertise in engineering to develop both a conceptual framework as well as a catalogue of requirements and assessment criteria for the examination and verification of recyclability.

This catalogue will be continually updated and, in particular, be brought up to date as it becomes necessary, taking into account technical changes that alter its classifications. In its most recent version, it is the valuation basis for certifying a product as "recyclable" by the Institute cyclos-HTP.

Recyclability is not a theoretical property. Defined correctly, it describes how well the material suitability of a product contributes to the closing of material cycles within the framework of established collection and recycling structures.

The widespread expansion and continuous development of recycling processes, in particular their extensive standardisation with regards to recognized state-of-the-art industry standards, were the impetus for the definition of general requirements for the design of products could make them accessible to recycling after usage.

To supplement the guidelines for recyclable packaging design, such as "Recoup" and "Recyclas", the Institute cyclos-HTP developed a requirements and assessment catalogue in 2011 that quantitatively measures the recyclability of packaging and other similar products for the first time.

After consultation with trade associations like IK, FKN and DAVR, this catalogue was published and has, since then, been updated regularly. Many brand manufacturers and producers of packaging material use this tool for defining on their status quo and optimizing the sustainability of their packaging. "Der Grüne Punkt" also evaluates the packaging of its licensees using this method.
1. **Assessment Framework and Methodology**

The main features of this method are:

- The benchmark for the assessment of recyclability are recycling processes, that bring about recyclate quantities replacing material identical virgin materials on a 1:1 basis.
- These reference processes have to be implemented and available on an industrial scale. This applies to the entire recovery chain, from collection to sorting and re-processing to the final recyclate.
- Real recycling processes are material-specific. Correspondingly, the assessment criteria are derived from the respective relevant reference processes.
- The quantitative assessment takes into account all possible uses at the closing of the material cycle. Thus, it ends up after completion of all separation, cleaning, melting and forming processes with the recyclate as a raw-material equivalent.
- The rating is between 0% (non-recyclable) and 100% (fully recyclable).

The assessment "100% recyclability" thus means that the packaging or product meets the material and physical prerequisites to become, after its initial use phase, a secondary product comparable to a material identical primary product.

In fact, this is a very rare rating because recyclability is not an end in itself but potentially secondary to the functional requirements of the product. For example, a paper label reduces the recyclability of a glass bottle, but is unavoidable as it bears consumer information. Or, to ensure the durability of a plastic film of polypropylene (PP), a barrier layer of another plastic (e.g. nylon) is incorporated which slightly reduces recyclability.

Recyclability is a relevant environmental requirement. It is also the basis for ecological assessment, but it is not in itself a direct ecological assessment indicator or category.

The following explanation serves to put "recyclability" into perspective as compared to ecological assessments such as "lifecycle analysis" (LCA) or "carbon footprint":

While the latter accounts for the pre-and post-usage phase, "recyclability" only focuses on the post usage phase. Therefore, the assessment value “recyclability” characterises not only the ecological but also the economic added value after the product has become waste. Recyclability is first of all an independent variable for saving of resources with recirculation and not an ecological valuation category. For production is also taken into account for the ecological assessment, comparisons between different products can lead to configurations in which a higher ecological benefit is associated with a lower degree of recyclability, for example, when much fewer resources are used to produce a product at the expense of its recyclability.
1. **Assessment Framework and Methodology**

In short: The assessment of recyclability is always part of an ecological assessment but cannot replace it. When comparing both figures, recyclability and ecological assessment categories can correlate, but they need not.

If a comparison of the recyclability is made, the named caveats must be taken into account. Unaffected by such limitations, the conclusions drawn regarding recyclability as an independent absolute quantifying parameter for the closure of material cycles and, with it, the related added value, remains.
2. Recyclable – What does It mean?

Recycling means closing loops. For this reason, the term "recycling" in this assessment catalogue is to be closely laid out according to this definition. In the following, recycling always means processing of materials without modification of the molecule structure to produce recyclates, regenerates, blends or alloys to replace corresponding virgin material in standard applications. This benchmark is illustrated by the red marking in figure 1.

Figure 1: Definition and delimitation of the term "recycling"

The basic understanding of closed-loop recycling, in which recycling material does not only replace corresponding virgin material but is also repeatedly used in identical primary applications, is hereby joined by a second level in which closed recycling loops may be implemented on a lower quality level. An example for this is the production of polyolefin-based regranulates made from, among other things, yoghurt cups and bowls. The application of these regranulates, such as in flower pots or pipes, replaces corresponding virgin material; however, it is limited, e.g. in coloring or in relation to contact with food, in comparison to actual virgin material. This quality of level 2 is, depending on new coloring, additives, etc. also achievable when the recycling process chain is run through repeatedly, so that potentially-closed loops can be realized after a first cascade level in the utilisation chain.

In contrast, material utilisation processes, which include secondary raw materials in production without replacing the virgin material typical for the respective application, are not regarded as recycling in the sense of this assessment catalogue. Utilisation processes that apply materials directly or indirectly as an energy source are also not taken into account.
2. Recyclable – What does it mean?

The declaration of a product, e.g. packaging, as "recyclable" or "100% recyclable" must have a substantial basis. This also helps to prevent public debates and legal arguments.

Important underlying principles include:

- DIN EN ISO 14021 "Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling)" – This standard requires that environmental product declarations must not be misleading but substantiated and verifiable. The property must be real and not only hypothetically met.

- DIN EN 13430 "Packaging - Requirements for packaging recoverable by material recycling" – This standard defines certain minimum requirements. For this assessment catalogue, additional requirements exceeding the standard, which are crucial for substantial verification and examination in accordance with DIN ISO 14021, are defined. These include:
  - Individual recyclability must be at least already specifically applicable to a relevant extent. Only the option of establishing recyclability in appropriate intervals is not sufficient.
  - For measurement and declaration of the the recyclable content of products consisting of different material components, which are only recyclable via different recycling paths, positive influence of the individual components is only declared if a respective diversifying separation is actually applied.
  - When measuring or declaring the percentage proportion of recyclability, the potential rate of substitution of the corresponding virgin material is applied instead of the interface of provisioning of secondary raw materials.

The term of recycling combines now established multi-stage, complex process chains on an industrial scale. Due to its advanced standardisation, the specific properties of a product can be assessed in the post-use phase.

Against the background of more than 25 years of practical experience with the framework conditions of recycling structures and the technical design of recycling processes, Institute cyclos-HTP has developed this requirements and assessment catalogue. Based on objective measures, the recyclability of used materials collected via available material collection schemes can be characterised in quality and quantity.

Based on the requirements placed on packaging with reusable materials according to DIN EN 13430, the relevant criteria have been put in concrete terms and further defined.
3. Research and Assessment Matrix, Overview and Process

Recyclability can be defined as qualitative and quantitative behaviour of a product in the post-use phase via the respectively specific process chain to primary raw material substitution. This means that it must be possible to collect the material using existing collection facilities and to sort it in a qualified manner. Its reprocessability must enable recirculation.

For assessment, reference schemes are required to realistically illustrate the existing processing structures in the relevant stages. During assessment, the product to be assessed runs through this simulated reference process chain. This reference process chain is denominated as a path. At this point in time we distinguish between 13 different paths. They all have in common that at the end of the process cascade, a recyclate is produced that can replace material identical virgin material. The assessment criteria are derived from the influencing parameters of the related stage of the specific process cascade.

A simplified decision tree illustrating the verification process is shown below. It also shows that the individual test steps (such as the technical processes themselves) are connected in a series, which means, that if in one of the steps a "Zero" or 0% is given, this is also the overall result.
3. Research and Assessment Matrix, Overview and Process

Packaging / Material identical non-packaging items

Assessment criteria according to test scheme

- C1: Percentage of recyclable material
- C0: Allocation to a recycling path
- C2: Identifiability by NIR
- C2': Discharge behaviour
- C3: Effective electrical conductivity
- C4: Ferromagnetism
- C5: Material density after disintegration
- C6: Dissolution rate in water
- C7: Melting behaviour (phase separation)
- C7: Melting behaviour
- C8: Inseparable contaminants

Recyclable contents?

yes / percentage

Collection and recycling structures available?

cy system losses

yes / different path

Target-oriented sorting possible?

yes / percentage

Technically recoverable?

yes / percentage

Regenerable?

yes / percentage

Qualitative classification?

high quality

Recyclability in %

Figure 2: Flowchart of the test process
3. Research and Assessment Matrix, Overview and Process

The reference processes (paths) applied for the preparation of this requirements and assessment catalogue as well as their technical requirements are specified in appendix 2. The individual countries providing specific collection and processing structures are specified as well.

The assessment or certification object is the product as a whole (packaging is assessed without its content). If utilisation requires the product to be disassembled into individual components, these are classified, examined and assessed individually. The overall result is then determined by adding up the weighted individual results. This is also valid if it is known by experience that a splitting up by the final user or by mechanical impact during transport can be assumed in general or as a minimum, is plausible.

If packaging cannot be fully emptied for technical reasons, filling material proportions, which always remain in the packaging after use, are incorporated qualitatively according to their separability and compatibility with the recyclate (see C8).

The following assessment matrix lists the individual recycling paths with their central respective assessment criteria. If a criterion is mandatory for the individual path, it is marked with an x. During the individual assessment, the entire cascade process is to be considered so that, in individual cases, criteria which are not relevant for the general case following table 1 are identified and added (e.g. size, format and surface weight).
3. Research and Assessment Matrix, Overview and Process

<table>
<thead>
<tr>
<th>Recycling Path</th>
<th>C0 Assignability to a recycling path</th>
<th>C1 Percentage of recyclable material</th>
<th>C2 Identifiability by NIR</th>
<th>C3 Electrical conductivity</th>
<th>C4 Ferromagnetism</th>
<th>C5 Material density after disintegration (2) or (3)</th>
<th>C6 Time(3) and yield(1) for dissolution in water</th>
<th>C7 Melting behavior</th>
<th>C8 Inseparable recycle contaminants</th>
<th>total score&lt;sup&gt;1) &lt;/sup&gt; 1 x 2 x 3 x 4 x 5 x 6 x 7 x 8 in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plastic foil</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1 x 2 x 3 x 4 x 5 x 6 x 7 x 8 in %</td>
</tr>
<tr>
<td>2. PE</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3. PP</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4. PS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5. PET</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6. Mixed plastics (rigid/dense)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7. Mixed plastics (soft/flexible)</td>
<td>X</td>
<td>(X)</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8. Beverage carton</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>9. Ferrous metals</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10. Non-ferrous metals</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>11. Paper cardboard composites</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>12. Glass</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>13. Paper, cardboard</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Please note: The values to be determined for criteria 5 and 7 refer to the proportion of recyclable material as specified under criterion 1.

Explanations of the individual criteria

C0: Path allocation

A superordinate criterion for classification of products according to their recyclability is the availability of an applicable collection and processing structure. This structure is required when the product can be attributed, with respect to its material content to one of the recycle pre-products listed under "path". If such an assignment is not possible, the recyclability typically cannot be verified unless specific, generally accessible collection and processing structures are available.

Thus, only specifications with an effective processing option for high-quality recycling, which are available to a significant extent, are listed.
3. Research and Assessment Matrix, Overview and Process

Attributability means that the product – subject to additional checks – is compatible with the specifications of the respective recycling technology according to its composition. All following criteria are applied or assessed path-specifically.

C1: Percentage of recyclable material

The "percentage of recyclable material" specifies the potentially recyclable mass proportion of the total mass of the product (new goods). C1 thus stands for the potentially recoverable recyclable proportion of material in the narrower sense of the word. If packaging cannot be fully emptied for technical reasons, these unavoidable filling material proportions are applied as related material component and respectively taken into account in the following qualitative assessment criteria.

The classification of recyclable or non-recyclable fractions correspond to the target product or impurity definition of the respective recycling process (path). The usually occurring correlations are specified in the following table.

Table 2: Overview of recyclable percentages

<table>
<thead>
<tr>
<th>Path</th>
<th>Percentage of recyclable material</th>
<th>Non-recyclable components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic foil; PE; PP; mixed-plastics rigid/dense and mixed plastics soft/flexible</td>
<td>PO-percentange</td>
<td>Other plastics; labels/sleeves</td>
</tr>
<tr>
<td>PS</td>
<td>PS-percentange</td>
<td>Other plastics; non-plastic material; labels/sleeves</td>
</tr>
<tr>
<td>PET</td>
<td>PET-transparent percentage; additional PO-percentage (caps)</td>
<td>Other plastics; labels/sleeves; non-PET</td>
</tr>
<tr>
<td>Beverage carton / plastic-coated cardboard packaging</td>
<td>Percentage of fiber</td>
<td>Plastic foil; non-ferrous foil; other packaging components; wet-strength fiber</td>
</tr>
<tr>
<td>Tin cans / ferrous metals</td>
<td>Percentage of ferromagnetic metal alloys</td>
<td>Plastic components; labels/sleeves</td>
</tr>
<tr>
<td>Aluminum / non-ferrous metals</td>
<td>Percentage of non-ferrous metals</td>
<td>Plastic components; labels/sleeves</td>
</tr>
<tr>
<td>Paper and cardboard composites</td>
<td>Percentage of fiber</td>
<td>Plastics; aluminum; wet-strength fiber</td>
</tr>
<tr>
<td>Glass</td>
<td>Glass and metal percentage</td>
<td>Plastic caps, labels/sleeves</td>
</tr>
<tr>
<td>Paper, cardboard</td>
<td>Percentage of fiber</td>
<td>Non-fiber incl. binding agent; wet-strength fiber</td>
</tr>
</tbody>
</table>
3. Research and Assessment Matrix, Overview and Process

The assessment factor is determined based on plausible manufacturer specifications on the product material composition. Generally, the result is applied directly proportional in the overall assessment result (exceptions see CAT 2).

High-quality recycling requires the separability of individual materials in a narrow sense. The currently established recycling processes are mostly focused only on one, rarely on a few materials whose admissible component and processing properties are specified in the respective products or recyclate characterisations according to DIN standard. All other components are regarded as process-specific contaminants.

With regard to the quality of contaminants, three categories are to be generally distinguished (the respective mass proportions are specified under C1 within the assessment): 

CAT 1: Materials, quantitatively separable by the treatment steps established in the recycling process. 

According to CAT 1, the proportion of contaminants leads to a quantitative limitation of the recyclability and is taken into account in C1 by respectively reducing the factor.

CAT 2: Materials, not separable by the treatment steps established in the recycling process, having no or negligible impact on the recyclate properties up to a defined relevant concentration.

The respective proportion is not added as accepted material (recyclable proportion) within assessment criterion C1. An exception is regular mixture components of the recyclate (alloy, blend, master batch) such as TiO\(_2\)-percentage in HDPE or HDPE-percentage in PP blends.

CAT 3: Materials, not separable by the processes established in the recycling treatments processes, degrading the quality of the recyclate to uselessness or otherwise lead to disproportionately high process costs.

The assessment of contaminant proportion of CAT 3 is specified under C8 and defines that the recyclability cannot be verified (factor 0).

The following table contains examples of typical "contaminants" of CAT 1 - 3 (i.e. particularly, neither final nor fixed assignment). In some cases, the assessment depends on the concentration. Therefore, individual assessments are applicable at all times. For this reason, the examination always includes research on potential incompatibility of inseparable material combinations and additives, printing colors, etc.
### Table 3: Overview of typical contaminants in individual recycling paths

<table>
<thead>
<tr>
<th>Path</th>
<th>CAT 1</th>
<th>CAT 2</th>
<th>CAT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Plastic foil</td>
<td>Paper labels; water-soluble adhesives; non-PO plastics</td>
<td>EVOH-barrier layer; (PP-caps*); labels</td>
<td>Non water-soluble adhesives combined with wet strength paper labels; components of EuPIA (exclusion list for printing inks and related products)</td>
</tr>
<tr>
<td>2 PE</td>
<td>Paper labels; water-soluble adhesives; plastics &gt; 1 g/cm³</td>
<td>EVOH-barrier layer; (PE-caps*); labels</td>
<td>Silicon components; expended plastics components; non water-soluble adhesives combined with wet-strength labels</td>
</tr>
<tr>
<td>3 PP</td>
<td>Paper labels; ALU lid(s); water soluble adhesives; plastics &gt; 1 g/cm³</td>
<td>EVOH-barrier layer; (PE-caps*); labels</td>
<td>Silicon components; expended plastics components; non water-soluble adhesives combined with wet-strength labels</td>
</tr>
<tr>
<td>4 PS</td>
<td>paper labels; aluminum lid(s); water-soluble adhesives; plastics &gt; 1,08 g/cm³</td>
<td></td>
<td>Other impurities, density range 1,0 – 1,08 g/cm³</td>
</tr>
<tr>
<td>5 PET</td>
<td>Plasma coating (clear); water-soluble or basic soluble adhesives; paper labels; PE, PP-labels and sleeves</td>
<td>AA-blockers UV-stabilizers</td>
<td>PET-G, PET-C; EVOH / PA-mono layer-barrier layer; PVC, PS, PET-G-labels/sleeves; non-soluble adhesives (water or basic at 80°C); non-ferromagnetic metals; elastomers with density &gt; 1 g/cm³</td>
</tr>
<tr>
<td>6/7 Mixed plastics</td>
<td>Paper labels; PS, PET, PA, PVC, ABS, PC, etc.</td>
<td>EVOH-barrier layer</td>
<td>Silicon components; expended plastics density&lt; 1 g/cm³ components of EuPIA (Exclusion list for printing inks and related products)</td>
</tr>
<tr>
<td>8/11 Paper and cardboard composites/ Beverage carton</td>
<td>Plastic labels; plastic and metal layers; plastic and metal parts; wet-strength paper; printing inks and adhesives; water-soluble inks and adhesives, re-dispersive; paper coating agents</td>
<td></td>
<td>Components of EuPIA (Exclusion list for printing inks and related products)</td>
</tr>
<tr>
<td>12 Glass</td>
<td>Paper and plastic labels</td>
<td>lead oxide</td>
<td>Glass composites with metal or plastic layers</td>
</tr>
<tr>
<td>13 Paper and cardboard</td>
<td>Plastic parts; wet strength paper</td>
<td>printing inks and adhesives; water-soluble inks and adhesives, re-dispersive; paper coating agents</td>
<td>Components of EuPIA (Exclusion list for printing inks and related products)</td>
</tr>
</tbody>
</table>

*percentage will be evaluated in a 75% ratio as product and 25% subtracted as unwanted*
C2: Identifiability in NIR reflection measurement / optical detectability

Materials that are separated by default using NIR spectrometric reflection measurements, i.e. that need to be pre-concentrated, are tested for compliance with the requirements of unambiguous detection with regard to the target fraction. If these conditions are not met, e.g. due to considerable labelling with foreign material or as a consequence of too dark colors caused by carbon black additives, the factor 0 is assigned. If correct identification depends on the position, this is taken into account; e.g. in the case of two-dimensional items whose two surfaces consist of different materials, for example a factor of 0.25, 0.5 or 0.75 (0.25 and 0.75 for two-stage process steps) is assigned. Factor 1 corresponds to unrestricted identifiability.

The determination is made on the basis of an empirical measurement under standardized conditions with operationally deployed classifiers (reference program) of the current generation.

For glass, the NIR reflection behaviour is replaced by the transmission of visible light.

C2’: Discharge behaviour

The sensor-based sorting methods show, compared to other separation techniques, the specialty that the separation of items is a separate stand-alone part of the process in particular independent of the detection of physical properties such as mass and shape.

The corresponding assessment (sub)criterion is called “separation behaviour”.

Measurement and quantification take place in a dynamic test under standard conditions variable in terms of pressure and valve block design.

A test result of >70% correct separation at positive registration is required for a positive unrestricted consideration of this criteria. A result of less than 30% leads to 0 (not separable) for C2’. In between 30% and 70% the factor is set to 0.5. If deductions are made, the cause for insufficient separation behaviour must be shown in the test certificate.

C3: Effective electrical conductivity

On the one hand, this criterion for materials to be recycled via the fraction non-ferrous metals/aluminum takes into account whether sufficient requirements for separation using the standard eddy current separation process are met. The classification separable (assessment factor 1) or insufficiently recyclable is carried out on empirical basics. Depending on the format, an examination of possible position dependency is also empirically carried out.
On the other hand, all other materials with a recycling path not defined according to the non-ferrous metal proportion of the article, except coated carton packaging, are assessed differently using the same measuring method: If the separation behaviour is defined by the metal proportion, the factor 0 applies for the examined recycling path; the product is then obligatory set using path 10 (aluminum/non-ferrous metals). If practically no relevant impact can be identified, factor 1 is set.

C4: Ferromagnetism

Ferromagnetic product properties are usually dominant for recyclability. In all standard recycling processes, this material property is applied for separation as one of the primary process stages. If the product has ferromagnetic components, it has to be checked first whether these are sufficient to define the recycling path. In borderline cases, this is regarded as fulfilled when the product can be lifted with a magnet system installed at an operational height of 450 mm from a distance of 300 mm.

If this is the case, the material is assessed independently of the other material proportion via the recycling path for tin plate / ferrous metals. Exceptions from this assessment benchmark are made for products that exceed a length of 220 mm in minimum 2 dimensions (for example a PE bucket with steel handle). In the actual recycling process, it can be assumed that these products are mechanically disintegrated prior to separation.

C5: Material density after disintegration

The density criterion takes into account the fact that float-sink sorting is the central process step to produce high-quality recycles within plastics reprocessing. Classification and assessment according to the density criterion are carried out after disintegration by grinding to approx. < 12 mm. The assessment criterion is whether the generated material parts are under or over the technically relevant separation density of 1 g/cm³ (PE, PP, PO cut) or 1.08 g/cm³ (PS).

If, for example, the above specified values are exceeded due to filling material or coating, the material is assessed as non-recyclable. Partly exceedance, unless already considered under C1, is quantitatively included in the assessment. (The application of incompatible plastics of one density class in a product within the plastics recycling process is managed under C1 or C8.)

The test for density criteria is usually done empirically. If theoretical testing is carried out and no specific manufacturer data are available, relevant substance data are applied.
A survey of data on commonly used substances is given in Appendix 1.

**C6: Dissolution rate in water**

If products are to be recycled using one of the existing recycling paths for waste paper, fibers need to be dissolved under the technical operation parameters of the paper recovery process.

As a reference for products to be assigned to path 13, the required pulping time for mixed waste-paper (type 1.02) is applied. For assignment to path 8 and 11, the dissolution time for beverage cartons is applied.

Fiber losses in reject are applied by a deduction factor of 1.

**C7: Melting behaviour**

Solid / liquid separation, as implied e.g. in melt filtration for regranulation of plastics, is basically assessed as other physical separation processes without phase change.

Materials or contaminants (see C1), that can only be separated from the recyclate proportion in molten condition are taken into account in the assessment of the recycling rate by a deduction factor of 2 as the solid / liquid separation is always connected with a loss of accepted material, which is to say, a loss of recyclate.

An estimation of which materials do not melt at the processing temperatures used in the re-melting to recyclates (about 230°C at PO and up to 285°C with PET), is provided in the material data collection in Appendix 1. If no specific manufacturer information exists, this information is used.

Process-intrinsic losses of recyclate due to evaporation or oxidisation is subject to a standard deduction based on documented data. The losses occurring during the pyrolysis of non-ferrous metals are subject to a standard deduction of 9.4% for aluminum and aluminum composites as well as 13.6% for aluminum-containing composites, respectively related to the proportion of non-ferrous metals (Source: Survey of VAW Aluminium AG: Ökologische Effizienz der stofflichen Verwertung der DSD-Aluminium-Verpackungs-Fraktion durch Pyrolyse [ecological efficiency of material recycling of the DSD aluminium packaging fraction by means of pyrolysis]; 2000).

Melting furnace losses during recovery of ferrous metals (evaporation of the tin content) are subject to a standard deduction of 70% of the tin proportion. (Source: Wullrich, W.; Schicks, H.: Presentation at the Duisburger Recyclingtage, Moers, 1992). Losses by oxidation of ferrous metals in a converter are not regarded for the time being. Pending further notice the losses are evaluated
as marginal and therefore not taken into account. Losses that occur during melting by oxidation of paint or additional plastic coatings are already taken into account under C1.

All losses are regarded as partly difference to the factor of 1, or 100%.

(For material systems with comparable melting behaviour or finely-dispersed inclusions, reference is made to C1 and C8 under observation of the mixing capability (blends, alloys, filling materials) and compatibility with the recyclate properties. The same applies for materials that are subject to decomposition in the temperature range of remelting required for recyclate production.)

The assessment regarding the incompatibility of inseparable foreign components is usually based on manufacturer's data (e.g., data from safety data sheets, data on thermal stability, specifications of adhesives, printing inks, etc.). If no specific substance data are available, the assessment is carried out as far as possible on the basis of relevant data.

Incompatibility based on the decomposition of material in the context of thermal forming processes is usually determined on the basis of the material data collection in Appendix 1.

C8: Inseparable contaminants / material-conditional cross contamination

If the product to be assessed contains contaminants of CAT 3 (see C1), economic production of marketable recyclate can no longer be assumed and the product is classified as non-recyclable (factor 0).

Overall assessment

In overall assessment, the determined individual factors C1 to C8 are multiplied. If the result is not 0, the result is classified as recyclable according to DIN EN ISO 14021.

The total score in % is configured in such a way, that it represents the proportion of the product that is actually available for monetary creation of value after application of high-quality recycling for resource saving.

A differential test certificate is issued on the classification. The overall assessment is indicated quantitatively as "% recyclable".

The certification entitles to use the test seal of the Institute cyclos-HTP to indicate the independent verification of the environmental label and declaration "recyclable". Rights and obligations of the utilisation of the seal are specified separately.

Instead of the number, the category of the degree of recyclability can also be specified. It is also specified on the test certificate.
3. Research and Assessment Matrix, Overview and Process

The following scale is to be applied:

<table>
<thead>
<tr>
<th>CAT</th>
<th>Recyclable, Recyclable Proportion</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT C</td>
<td>recyclable, recyclable proportion</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>CAT B</td>
<td>recyclable, recyclable proportion</td>
<td>50% - 70%</td>
</tr>
<tr>
<td>CAT A</td>
<td>recyclable, recyclable proportion</td>
<td>70% - 90%</td>
</tr>
<tr>
<td>CAT AA</td>
<td>recyclable, recyclable proportion</td>
<td>90% - 95%</td>
</tr>
<tr>
<td>CAT AAA</td>
<td>recyclable, recyclable proportion</td>
<td>&gt; 95%</td>
</tr>
</tbody>
</table>
### 4. Appendices

#### 4.1 Appendix 1: Material data collection

<table>
<thead>
<tr>
<th>short symbol</th>
<th>name</th>
<th>density</th>
<th>glass transition temperature $T_g$ or melting point $T_m$</th>
<th>decomposition temperature / remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-LD</td>
<td>Polyethylene low density</td>
<td>0.915-0.935 g/cm³</td>
<td>$T_m$: 105-118°C</td>
<td>340-440°C</td>
</tr>
<tr>
<td>PE-HD</td>
<td>Polyethylene high density</td>
<td>0.94-0.97 g/cm³</td>
<td>$T_m$: 126-135°C</td>
<td>340-440°C</td>
</tr>
<tr>
<td>PP</td>
<td>Polypropylene</td>
<td>0.91 g/cm³</td>
<td>$T_m$: 160-170°C</td>
<td>330-410°C</td>
</tr>
<tr>
<td>PS</td>
<td>Polystyrene</td>
<td>1.05-1.06 g/cm³</td>
<td>$T_g$: 100°C (ataktisch) $T_m$: 240 - 270°C</td>
<td>300-400°C</td>
</tr>
<tr>
<td>EPS</td>
<td>Expanded polystyrene</td>
<td>0.015-0.1 g/cm³</td>
<td>$T_m$: ~ 240°C</td>
<td>300-400°C</td>
</tr>
<tr>
<td>PET-A</td>
<td>Polyethylene terephthalate amorphous</td>
<td>1.33-1.35 g/cm³</td>
<td>$T_g$: ~ 80°C $T_m$: ~ 260°C</td>
<td>from 340°C</td>
</tr>
<tr>
<td>PET-G</td>
<td>Polyethylene terephthalate glycol modified (copolymer)</td>
<td>1.27 g/cm³</td>
<td>$T_g$: ~ 80°C $T_m$: ~ 260°C</td>
<td>from 280°C</td>
</tr>
<tr>
<td>PET-C</td>
<td>Polyethylene terephthalate partially crystalline</td>
<td>1.38-1.40 g/cm³</td>
<td>$T_m$: ~ 280°C</td>
<td>320°C</td>
</tr>
<tr>
<td>PA 6</td>
<td>Polyamide 6</td>
<td>1.13 g/cm³</td>
<td>$T_g$: 40 - 45°C $T_m$: 220 - 225°C</td>
<td>300-350°C discoloration by thermolysis-oxidative degradation from 200°C</td>
</tr>
<tr>
<td>PA 66</td>
<td>Polyamide 66</td>
<td>1.14 g/cm³</td>
<td>$T_g$: 50 - 60°C $T_m$: 250 - 260°C</td>
<td>320-400°C discoloration by thermolysis-oxidative degradation from 200°C</td>
</tr>
<tr>
<td>EVAL; EVOH</td>
<td>Ethylene-vinyl alcohol (copolymer)</td>
<td>1.21 - 1.31 g/cm³</td>
<td>$T_m$: 165-183°C depending on the mole%</td>
<td>ab 200°C</td>
</tr>
<tr>
<td>PVAL; PVOH</td>
<td>Polyvinyl alcohol (copolymer)</td>
<td>1.19 – 1.31 g/cm³</td>
<td>$T_m$: 200 - 228°C</td>
<td>180 - 200°C</td>
</tr>
<tr>
<td>PVC (hard)</td>
<td>Polyvinyl chloride</td>
<td>1.40 g/cm³</td>
<td>$T_g$: ~ 80°C</td>
<td>from 180°C pure PVC: 200-300°C; browning by HCL-cleavage from 180°C</td>
</tr>
<tr>
<td>PVDC</td>
<td>Polyvinylidene chloride</td>
<td>1.63 g/cm³</td>
<td>$T_m$: 200°C</td>
<td>225-275°C browning by HCL-cleavage from 180°C</td>
</tr>
<tr>
<td>POM</td>
<td>Polyoxymethylene</td>
<td>1.42 g/cm³</td>
<td>$T_m$: 175°C</td>
<td>from 220°C</td>
</tr>
<tr>
<td>PMMA</td>
<td>Polymethylmethacrylate</td>
<td>1.18 g/cm³</td>
<td>$T_g$: 100 - 120°C $T_m$: 160°C</td>
<td>180-280°C</td>
</tr>
<tr>
<td>PAN</td>
<td>Polyacrylonitrile (copolymer)</td>
<td>1.17 g/cm³</td>
<td>$T_m$: 326°C</td>
<td>homopolymer &gt; 200°C</td>
</tr>
<tr>
<td>PC</td>
<td>Polycarbonate</td>
<td>1.20 g/cm³</td>
<td>$T_g$: ~150°C $T_m$: 220-230°C</td>
<td>350-400°C</td>
</tr>
<tr>
<td>PEN</td>
<td>Polyethylene naphthalate</td>
<td>1.36 g/cm³</td>
<td>$T_m$: 270°C</td>
<td></td>
</tr>
<tr>
<td>Al</td>
<td>Aluminum</td>
<td>2.7 g/cm³</td>
<td>$T_m$: 660°C</td>
<td></td>
</tr>
<tr>
<td>CaCO3</td>
<td>Calcium carbonate / chalk</td>
<td>2.73 g/cm³</td>
<td></td>
<td>825 - 899°C</td>
</tr>
</tbody>
</table>
4. Appendices

4.2 Appendix 2: Reference scenarios including explanations

- Overview - Lightweight packaging / recyclables
- Recycling path 1: Plastic foil
- Recycling paths 2 and 3: PE and PP
- Recycling path 4: PS
- Recycling path 5: PET
- Recycling path 6: Mixed plastics (rigid/dense)
- Recycling path 7: Mixed plastics (soft/flexible)
- Recycling path 8: Beverage carton / plastic-coated carton packaging
- Recycling path 9: Tin plate / ferrous metals
- Recycling path 10: Aluminum / non-ferrous metals
- Recycling path 11: Paper and cardboard composites
- Recycling path 12: Glass
- Recycling path 13: Paper, cardboard
4. Appendices

4.2.1 Overview – Lightweight packaging / recyclables

Reference scenario recyclability, overview (dated 01/2013)
Collection scheme lightweight packaging / recyclables

Collection

Sorting

Reprocessing

modules of reprocessing

Reference scenario recyclability, overview (dated 01/2013)
Collection scheme lightweight packaging / recyclables
4. Appendices

The sorting of lightweight packaging does not constitute its own separate path. Because of their particular importance as a partial reference for the paths 1 to 11, a detailed description of the current state of the art is here given. MRFs in other countries (such as PMD-Sorting in Belgium or KFF plus in the Netherlands) also follow comparable standards and process sequences so that a German-focused description of lightweight packaging sorting also applies in large part to those applications as well.

The reception area of a state-of-the-art lightweight packaging/material sorting plant is designed as a fully enclosed flat bunker. Delivery is partly carried out directly, by means of collection vehicles, but more predominantly, this work is done from handling transfer stations plants by means of container trucks or walking floors trucks.

Lightweight packaging/material has a very low bulk density. In its bulk state, as is relevant for the overall mechanical design, only 25 kg/m³ to 40 kg/m³ is estimated. As a result of compression during transport, however, the material mixture has even higher bulk densities upon delivery; at 4m high stacks, a 100 kg/m³ density and a storage area requirement of 2.5 m²/t plus driving and unloading areas have to be taken into consideration.

Due to differing delivery and operating times, the delivered material is mostly stacked first by means of a wheel loader; in parallel, and also by means of a wheel loader, the system infeed is carried out by means of a sub-surface conveyor belt or overhead system (dosing feeder, feed hopper).

A rough overview of current best practices for lightweight packaging/material sorting is given in the flowchart below. The figure also shows the resulting products of a modern, state-of-the-art lightweight packaging/material facility. The product names are abbreviated in the figure, but for exact identification and description, please refer to the list of varieties of the Dual Systems [available at http://www.gruener-punkt.de/en/download.html].

Today's existing facilities have only partially incorporated all of the elements necessary to make them state-of-the-art. In the basic procedure, however, standardisation has been reached. This results from the fact that the lightweight packaging/material collection plants are largely uniform throughout Germany, and uniform requirements are also placed on the sorted products.
4. Appendices

Figure 3: Schematic of the current state-of-the-art lightweight packaging / material sorting process

The bag opening always forms the input stage of the process. The objective of this step is the complete mechanical rending not only of collecting bags, but also of small, closed containers in particular, such as, for example, garbage bags. Through this process, all individual components are released. This is an obligatory prerequisite for the operability of all downstream operations within the process. As it stands now, this partial operation is usually executed in two stages and is coupled to a volumetric metering. As an alternative to two bag openers connected in series, slow-running pre-shredders (single-shaft shredder or rotary shears) have also proven to be reliable, for which, by means of relevant implementation, only bag opening and not disintegration of the material inside takes place.

**Screening and Wind Sifting**

The first separation stage is made up of a screening step that grades material from coarse to fine into 3 to 5 particle size classes, which are produced by means of 3 or 4 screen machines. The first screening machine has, in addition to this grading function, some other core functions, which include to empty opened bags, the further homogenisation of the volume flow, and, if applicable,
the distribution of volume flows to parallel sorting lines. Best practice dictates that only trommel screens equipped with mesh blinded sections or that is clearly below the separation size be used in order to ensure the emptying of bags in the infeed area. Moreover, the prevention or, at the very least, minimisation of accretion of the screen machines is achieved through wrapping protection, which involves the wrapping of bands and plastic foil. The design of the wrapping protection usually consists of rectangular or round pipe sections of approximately 150 mm length, which are applied from the outside to the drum body.

The target of concentration of large-format materials in the overflow of the first drum machine fulfills several functions. Primarily, it is used to limit the flow of material which is automatically sorted further downstream with regard to the grain class of what can be processed. In addition to that, an initial accumulation of large-sized plastic foil is achieved, which is then set aside as a separate type. A cut size of 220 mm has proven effective for this so-called primary screening. Depending on the capacity of the plant, sub-fractioning is also carried out for distribution to several functionally identical lines.

For throughputs up to approx. 1000 m$^3$/h, drum screens up to 3.8 m in diameter and up to 18 m effective screen lengths are put in place.

The screen overflow (approx. 10-15% of the input flow, and below referred to as coarse grain) is passed through wind sifters for the separation of plastic foil. The current best practice is a layout that utilizes cross-flow wind sifters with lightweight material discharged via rotary valve. The remaining heavyweight material can then be sorted manually. Additionally, the coarse heavyweight material is subsequently shredded in order to make it available for the mechanical and automatic sorting processes of the medium-sized grain lines.

A second sorting screen section is set for fine grain. For wear protection, current practice is to eliminate virtually all non-recyclable fine grain by 20 mm mesh within flat screens. The fine grain fraction is usually about 5%.

The main mass flow (20 mm to 220 mm, approx. 80% to 85% of the input flow) is also conducted via wind sifters after screening. In high-capacity plants, the material flow is split over the screening machines, and the wind sifting, just as the subsequent process stages, is performed in parallel lines. Unlike in the case of coarse granulation, the purpose of separating medium-sized grain is not to create a product, but rather to prepare recyclable fractions for downstream sorting processes: lightweight packaging is a mixture with extremely low bulk density, which is largely due to the content of plastic foil in almost double-digit range. All modern sorting techniques require a
monolayer material flow, which cannot be delineated without extensive removal of extremely thin-walled, flat components. The light material of the medium-sized grain wind sifting (approx. 10% of the input tonnage and with a bulk density <10 kg / m$^3$) is discharged as mixed plastic. Depending on the paper content of the lightweight packaging material collected, an automatic secondary cleaning is necessary beforehand.

**Magnetic Separation**

The next step in the process chain is the separation of ferromagnetic components (essentially tinplate) by means of suspension magnet separators (9-13% of the input flow). The product of the magnetic separation is generally not cleaned further. In a state-of-the-art facility, the suspension magnets are installed lengthwise over a transfer point of a conveyor belt, and the feed belt is set up as a regulated, fast-running belt in order to minimize missorting due to the overlapping of material. Splitters are also designed as drums which rotate against the direction of the belts. This is done for the purpose of optimizing product purity, as well as avoiding blockages. Additionally, rotating splitters are also standard in eddy current separators and sensor-based sorting machines.

Subsequently, the remaining material flow, in which rigid/dense plastics, non-ferrous metals, liquid cartons and other materials, as well as impurities such as paper and cardboard, have accumulated, is fed to a cascade of automatic separation stages with intermediate eddy current separation.

**Eddy Current Separation**

Eddy current separation serves to separate metallic, non-ferromagnetic components; from the standpoint of the packaging sector, only aluminum is relevant here. The system is set up in such a way that liquid cartons with aluminum coating, that have not been sorted out by upstream NIR-beverage carton sorting, are discharged into the product flow, which necessitates its subsequent purifying via a NIR separation stage.

The principle behind eddy current separation is based on the induction of electrical currents in electrically-conductive materials by a high-frequency magnetic alternating field.

This is implemented by means of a rotor that is covered with high-intensity permanent magnets in alternating polar order and which is then rotated in a conveyor belt head drum at high speeds.

The current induced in the conductive particle forms a separate magnetic field, which is always opposed to the alternating field of the machine. The resulting repulsion leads to the deflection of electrical conductors from the flow. Ferromagnetic fractions are attracted and must therefore be separated before the eddy current separation.
The deflecting force is relatively low compared to the attracting force of a magnetic separation. The ratio of electrical conductivity to mass can simplified been defined as the separating characteristic. In addition, the shape of the electrical conductor plays a major role; a precondition for separation is that the induced current flows directionally. Therefore, an aluminum foil which is crimped into the ball cannot be separated well.

The description of the separation principle makes it clear that the technique is essentially suitable for separating all electrically conductive waste material, i.e. all metals. Aluminum, with a conductivity of 35 m/(Ω·mm²) at a density of 2.7 g/cm³, has a different conductivity than, for example, lead (conductivity 4.82 m/(Ω·mm²), density: 11.34 g/cm³). Correspondingly, different machine types can be used depending on the application, which differ essentially in the type and configuration of the magnet system.

Eddy current separators are necessary in facilities that sort lightweight packaging only for fine and medium size flows, since aluminum packaging is not contained in coarse material. Materially-identical non-packaging items (NVPs) are represented over the entire spectrum. According to relevant analyses, up to 70% can be generated in the size class > 220 mm. A sorting for coarse heavy material, whether by secondary grinding and re-circulation, or by manual sorting, is minimally recommended for extended (not only packaging) schemes of dry recyclables sorting.

**Sensor-Based Sorting**

The automatic separation stages (processing technology: sensor-based sorting = single particle sorting) differ from all other basic processing operations of sorting in that different material properties need not be simultaneously usable for physical separation. It is possible to separate that which can be differentiated by measurement technology. A disadvantage is the comparative principle-dependent throughput weakness and the high dependence of the separation success on the possibilities of material separation. Typical of this sorting type are detection methods and discharge devices which enable separation from a monolayer at high transport speeds.

The most important detection method in the field of light packaging/material sorting is near-infrared spectrometry, with which plastics and other hydrocarbon-containing materials are differentiated. The detector is arranged over an accelerator belt just before a belt transfer point. The conveying speed is up to 3 m/s. Radiation from a conventional halogen light source reflected from the near-surface layers of an object is measured. The emitted spectrum is compared in the process computer with reference values. In the case of positive detection, a targeted pulse of compressed
air is triggered based on the coordinates of the object by means of a valve block (valve distance 16 mm to 33 mm) set into the transfer point, which then leads to the deflection of the target object.

State-of-the-art facilities have up to 20 of these sorting machines in different functions. In addition to pure NIR separators, specific applications are also used which implement several types of detection (e.g. NIR, color measurement and induction measurement) in one machine (known as multi-sensor separators).

In lightweight packaging/material sorting plants, the process for separating liquid cartons, as well as for the collective plastic separation, is correspondingly automated. State-of-the-art systems also have a sub-fractioning out of form-stable plastics by type of plastic. A separation of standard packing plastic polymers HDPE, PP, PET, and PS takes place at this point. This process methodology was first implemented successfully in 1999 as a modular retrofit option and is now found in nearly all plants with a larger capacity, though not all four fractions are always produced.

**Conveyor Technology**

The conveyor system is an integral part of the processes used in sorting plants. This is true for magnetic separation, air sifting and eddy current separation, the operability and efficiency of which depends on thin- or monolayer loading. The functional dependency of the success of the sensor-based sorting systems must be emphasized in particular. The singling out of components that are to be separated is a prerequisite for this.

Both a continuous material flow and a uniform distribution of the material over the usable widths of the conveyors must be ensured. Sensor-based sorting units are available in system widths up to 2.8 m. In the sorting of light packaging, specific throughputs, which have to be applied depending on a partial flow between 0.5 t/h and 3 t/h per meter of system width can only be suitably put into place in accordance with the aforementioned preconditions.

Current state-of-the-art practice is to set up all the conveying components in such a way that in areas of separation processes, there are no surge-type stresses, one-sided loadings, or other such complications. This must be ensured by constant volume metering; avoidance of elevating conveyor belts, conveyors with cleats, and right-angled transfers points with low transfer heights at sensitive positions; if at all possible, straightforward design of sorting cascades; suitable layout of transfer points; and the use of vibrating feeders, as needed.
Manual Product Inspection

Despite all the automation, it is not possible at current standards to completely dispense with manual sorting. This is essentially due to systematic false sorting of materials in the automatic or mechanical separation stages. These are, in fact, not errors, but rather result from certain materials not corresponding to the separation characteristics being looked for by the automated systems. The cause of this comes down to something in the composite nature of some material or in limitations to the process of singling out specific items. For example, paper covered by LDPE foil is in the reference range for liquid cartons. Liquid cartons, which due to their aluminum inner coating are erroneously discharged by the eddy current separator, are a further example of a systematic discharge error. Also, the sorting task may not be completed with correct recognition of a material type, since the evaluation in a particular case requires yet another limiting factor. For example, PE foils in the sorting product PE are undesirable; silicone cartridges made of PE are even completely excluded due to the possible residual contents.

In industrial large-scale plants, such deficits of single-stage mechanical and automatic separation are, however, further reduced by secondary cleaning processes. But here, too, the option is open to carry out a manual follow-up. This is why even the most modern systems have a sorting cabin which provides optional access to all sorting products before buffering and baling.

In contrast to the systems utilized in other areas of waste material sorting, there are no continuous sorting belts in the area of lightweight packaging/material sorting cabins. The products are fed into the cabin on belts and end above the respective product bins. In some plants, the remainder left over from the sorting process is also conveyed again into the sorting cabin for visual inspection of how well the plant is operating at that time.

Places for required sorting personnel are equipped with air curtain ventilation with a supply of conditioned external air and waste heat recovery. To optimize energy efficiency, waste heat from the compressors required for the sensor-based sorting units can be used for heating purposes.
4.2.2 Recycling path 1: Plastic foil

Reference scenario recyclability, plastic foil (dated 01/2013)
Collection structures for plastic foils can be assumed in the following countries without further assessment:

- Germany
- Netherlands
- Norway

Plastic foils are pre-concentrated in the sorting process by grading and wind-sifting. The target fraction is narrowed down (generally > A4) in order to ensure a significant enrichment of LDPE.

A uniform standard process of foil recycling is wet processing with the processing stages of grinding, washing, sink/float separation, drying and extrusion with melt filtration.

Accordingly, to assess recyclability, the following process technology is usually required:

- wind-sifting for foil sorting
- Washing and qualified float-sink separation
- No additional requirements like hot washing, washing additives, etc.
- Extrusion with melt filtration
4.2.3 Recycling paths 2 and 3: PE and PP

Reference scenario recyclability, PE and PP (dated 01/2013)
Collection structures for PE and PP packaging can be assumed in the following countries without further assessment:

- Germany
- Netherlands
- Norway

With the additional attribute "Bottle and / or container" also in:

- Belgium
- Spain
- France
- Italy
- Austria
- Switzerland

PE and PP are specifically sorted out in large-scale sorting plants using NIR-based sorting machines.

Further recycling is carried out uniformly by means of wet processing with the processing stages of grinding, washing, sink/float separation, drying and extrusion with melt filtration to a HDPE or PP regranulate.

Accordingly, to assess recyclability, the following process technology is usually required:

- NIR detection for PE/PP (22.5 mm maximum valve distance)
- Ideal conditions for NIR detection of small / small format material
  - High-resolution detection
  - Valve distance ≤ 16.5 mm
- Integration of the entire grain range > 20 mm by return and / or manual sorting in coarse grain > 220 mm
- Washing and qualified float-sink separation
- Extrusion with melt filtration
4. Appendices

4.2.4 Recycling path 4: PS

Reference scenario recyclability, PS (dated 01/2013)
4. Appendices

Collection structures for PS packaging can be assumed in the following countries without further assessment:

- Germany
- Netherlands
- Norway

For waste collection schemes from the Netherlands, however, PS is not compulsorily sorted as a "monofraction". Additionally, the conceivable alternative path concerning preparation of stable plastics (wet-processing mixed-plastic preparation with PS recovery) is currently not practiced, which means that there currently is no high-quality recycling structures that exist.

German sorting plants are for the most part equipped with specific separation stages for (form-stable) PS related to processing quantity.

The sorting product is turned into PS regranulate exclusively by means of wet processing, with the processing stages of grinding, washing, sink/float separation (twice: at $1 \text{ g/cm}^3$ and approx. $1.08 \text{ g/cm}^3$), drying, and extrusion with melt filtration.

Accordingly, to assess recyclability, the following process technology is usually required:

- NIR detection for PS (22.5 mm maximum valve distance)
- Ideal conditions for NIR detection of small / small format material
  - High-resolution detection
  - Valve distance $\leq 16.5$ mm
- Washing and qualified float-sink separation
- Extrusion with melt filtration
4. Appendices

4.2.5 Recycling path 5: PET

Reference scenario recyclability, PET (dated 02/2017)
Collection structures for PET beverage bottles can be assumed in the following countries without further assessment:

- European Union
- Switzerland

In Germany, France, Belgium and the Netherlands, non-beverage bottle PET is also collected. However, recovery options only currently apply to transparent PET-A and not to other types, such as PET-C and PET-G or opaque PET.

In Belgium, non-beverage bottles are currently not allowed to be included in the sorting product, which means that, for Belgium, no recycling structures can be assumed at present.

PET, if not included in the mono-flow as a beverage bottle, is sorted out in all large-scale sorting systems via NIR-based sorting machines. However, it is also true that bottles for which a deposit is paid by the consumer must be identifiable in the NIR spectral analysis since the PET recyclers carry out an automatic control sorting of their input. Related to color and material.

Furthermore, according to current EU standards, it can be assumed that PET recyclers have multi-stage washing processes, of which at least one stage is designed for alkaline hot-wash.

Recovering the cap material (HDPE or PP) via sink/float separation is also standard. PET recyclers often do not regranulate the ground material, but sell the PET recyclates as "flakes". However, the remelting process is always part of the recycling process, independent of the recyclate input, whether it be bottles, film, packaging straps or fibers. This takes place at the processors, at the latest. Owing to the high melting point of PET, its high sensitivity to organic impurities, such as from other plastics or adhesives, must be considered, especially with clear PET, which can significantly reduce the amount of recyclate due to temperature-induced decomposition or color changes.

Accordingly, to assess recyclability, the following process technology is usually required:

- NIR detection for PET
- Two-stage washing with at least one alkaline hot washing process and qualified float-sink separation
- Extrusion with remelting temperatures up to 285°C and with melt filtration
4.2.6 Recycling path 6: Mixed plastics (rigid/dense)

Reference scenario mixed plastics rigid/dense (dated 01/2013)

Collection

Sorting

- Bag opening
- Classification
- Windsifting
- Magnetic separation
- NIR paper/beverage carton/PET
- NIR beverage carton
- Eddy-current separation
- NIR standard polymers
- NIR mixed plastics
- NIR paper and board
- Beverages carton
- Non-ferrous metals
- Mixed plastics rigid
- PET
- PS
- PP
- PE
- Paper and board
- Residue
- Ferrous metals
- Mixed plastics soft
- Foils

Reprocessing

- Grinding
- Wet cleaning
- Density separation
- Melting / Filtration
- Recyclate

Process steps, specific with no relevance
Process steps to be considered in individual cases
Process steps, significant
Collection structures for mixed plastics rigid/dense can be assumed in the following countries without further assessment:

- Germany
- The Netherlands
- Norway

Recycling capacity for high-quality material recycling of mixed plastics is currently concentrated in Germany. Specifically, the actual recyclable fraction is the polyolefin fraction. The supply of mixed plastics for high-quality material recycling is also not mandatory in Germany; however, there are considerable capacities present. They are competing for the energetic mixed plastics recovery and intrusion processes. It should be assumed that, with increasing demands on recycling, the importance of high-quality mixed plastics recycling will increase.

In most cases, mixed plastics are already set up during the sorting process according to the special requirements of these systems; suitable input materials are PS and (mixed) polyolefins, whether flexible, rigid or semi-rigid (HDPE, LDPE, PP). The treatment is achieved in a way that's fundamentally comparable to that of monosorts, namely by grinding, washing, sink/float separation, drying and extrusion with melt filtration. Products (regranulates) are blends e.g. for injection moulding applications.

Accordingly, to assess recyclability, the following process technology is usually required:

- NIR detection for plastics (22.5 mm maximum valve distance)
- Ideal conditions for NIR detection of small / small format material
  - High-resolution detection
  - Valve distance ≤ 16.5 mm
- Integration of the entire grain range > 20 mm by return and / or manual sorting in coarse grain > 220 mm
- Washing and qualified float-sink separation
- Extrusion with melt filtration
4.2.7 Recycling path 7: Mixed plastics (soft/flexible)

Reference scenario recyclability, mixed plastics soft/flexible (dated 01/2013)
Collection structures for mixed plastics soft/flexible can be assumed in the following countries without further assessment:

- Germany
- The Netherlands
- Norway

Recycling capacity for high-quality material recycling of mixed plastics is currently concentrated in Germany. Specifically, the actual recyclable fraction is the polyolefin fraction. The supply of mixed plastics for high-quality material recycling is also not mandatory in Germany; however, there are considerable capacities present. They are competing for the energetic mixed plastics recovery and intrusion processes. It should be assumed that, with increasing demands on recycling, the importance of high-quality mixed plastics recycling will increase.

In most cases, mixed plastics are already set up during the sorting process according to the special requirements of these systems; suitable input materials are PS and (mixed) polyolefins, whether flexible, rigid or semi-rigid (HDPE, LDPE, PP). The treatment is achieved in a way that's fundamentally comparable to that of monosorts, namely by grinding, washing, sink/float separation, drying and extrusion with melt filtration. Products (regranulates) are blends e.g. for injection moulding applications.

Accordingly, to assess recyclability, the following process technology is usually required:

- Wind-sifting in the grain range of 20-220 mm
- NIR detection for paper, tetra and PET in the light fraction of the wind-sifter (cleaning stage)
- Washing and qualified float-sink separation
- Extrusion with melt filtration
4.2.8 Recycling path 8: Beverage carton / plastic-coated carton packaging

Reference scenario recyclability, beverage carton (dated 11/2016)
Collection structures for plastic-coated carton packaging (tetra) can be assumed in the following countries without further assessment:

- EU and Switzerland

Drink cartons are collected together with lightweight packaging in Germany. In most other European countries, there is a comparable allocation (e.g., PMD in Belgium, etc.). As a rule, liquid cartons form a separate sorting fraction within the sorting process, which is generated in high-tech plants exclusively via sorting machines. (Liquid cartons have a specific spectrum in the NIR reflection measurement.)

The fraction "liquid packaging board" is assigned to special waste paper processing lines which are designed for the comparatively long pulping time (approx. 15 min.).

Accordingly, to assess recyclability, the following process technology is usually required:

- NIR detection for liquid packaging (tetra) in the light fraction of the wind-sifter, wind-sifter heavy fraction and in the eddy current separator product
- Pulping process with standard retention time
- Separation of insoluble components by classification

For liquid packaging board from German collections, it should be particularly noted that, in the meantime, a significant fraction of material rejected from the pulping is further processed.

Products of this certified recycling pulping process are aluminum granules and LDPE regranulates, which replace primary virgin material in respective material-specific (high-quality) applications.

As long as the corresponding recycling paths are activated, the prerequisites are also met for the aluminum and LDPE portions of a liquid carton to be classified as recyclable.
4.2.9 Recycling path 9: Tin plate / ferrous metals

Reference scenario recyclability, ferrous metals (dated 01/2013)

Collection

Sorting

Reprocessing

Process steps, specific with no relevance

Process steps to be considered in individual cases

Process steps, significant
Collection structures for tin plate and ferrous metals can be assumed in the following countries without further assessment:

- EU and Switzerland

The recyclability of ferrous metals and alloys via the corresponding recycling path is directly linked to the “ferromagnetic” property of the material. Non-ferromagnetic iron or steel products such as iron castings or high-alloy steels do not satisfy this criterion and are evaluated under path 10, as required.

Current best practice is the use of suspension magnets to sort material with weak-field magnetic separators. Because magnetic separation is generally placed early in the sorting process sequence, the “ferromagnetic” characteristic is considered dominant. Small ferromagnetic components such as, for example, the tinplate of a composite can or the metal hooks of a (plastic) coat hanger are sufficient to transfer the package or product into the sorting fraction “Fe-metals”.

Further processing of the sorting fraction generally comprises mechanical secondary cleaning for the separation of organic impurities (paper labels, plastics, residual contents) and of extraneous metals (in particular aluminum).

Process steps are disintegration by means of special shredders, such as, for example, the so-called Turbo-Crusher, wind sifting, nonferrous and ferrous separation and a final compacting of the sorted ferrous scrap to appropriately-sized units, which are generally used in steel production within the converter stage.

Accordingly, to assess recyclability, the following process technology is usually required:

- Magnetic separation for ferromagnetic components
- Operation height of the suspension magnet separator 450 mm
- Integration of the entire grain range > 20 mm by return and / or manual sorting in coarse material > 220 mm
- Ferrous metal recovery with magnet and eddy current separation
- Shredder process and subsequent eddy current separation for non-ferrous metal separation
4.2.10 Recycling path 10: Aluminum / non-ferrous metals

Reference scenario recyclability, non-ferrous metals (dated 01/2013)
Collection structures for aluminium and non-ferrous metals can be assumed in the following countries without further assessment:

Collection schemes for post-consumer non-ferrous metal packaging are installed in most European countries. The organisation varies and takes national specialties into account.

The different recycling paths can be classified as follows:

1. Separate collection of drink cans, either via deposit systems (northern countries, Germany) voluntary return systems (central and eastern countries, Turkey) or incentive-based schemes (UK, Ireland, France, Greece, etc.). Especially drink cans and menu trays are part of the separate collection scheme in UK and Switzerland (also tubes and caps).

2. Collection schemes where aluminium packaging is put of the collection scheme for mixed packaging waste together with packaging made of plastic, ferrous metal, drink-cartons and partly also paper and OCC (Italy, Spain, Germany, Portugal, France, Belgium, Austria). Aluminium packaging is then separated in sorting facilities. In Germany also compounds or composites with aluminium-foil are in scope of scheme. In the other mentioned countries, just items where the main component is aluminium like cans and menu trays are in scope.

The sorting fraction is generated uniformly via eddy current separators, which sort the flow by electrical conductivity. Aluminum is a comparatively good electrical conductor, like copper, so that sorting is carried out with very high efficiency. Since, in particular, mass and format play an overlapping role, the sortability is examined empirically. It is also tested whether the test object reliably arrives at the separating stage after the processes that lie upstream, such as sieving, air sifting and magnetic separation.

The aluminum fraction is subsequently processed further through pyrolysis. In this process, the material is thermally treated under oxygen-less conditions in order to detach gaseous organic elements, such as plastic coatings, lacquers, residual contents, etc. The portions in question are then deducted for the assessment. Subsequent treatment step is remelting, in which oxidized aluminum is slagged. These losses are also taken into account in the test results.

3. Recovery from MSW (mechanical pre-treatment MBT or MT) e.g. in Netherlands.

To assess recyclability*, the following process technology is usually required:

- Eddy current separation for metal components with mixed-pole system and eccentric magnet wheel
- Integration of the entire grain range > 20 mm by material feed-back and / or manual sorting in coarse grain > 220 mm

* The reference scenario is not applicable for aluminium-recovery from bottom ashes.
4.2.11 Recycling path 11: Paper and cardboard composites

Reference scenario recyclability, paper and cardboard composites (dated 01/2013)
Collection structures for paper cardboard composites can be assumed in the following countries without further assessment:

- Germany

To assess recyclability, the following process technology is usually required:

- NIR detection for paper cardboard and paper and tetra
- Integration of the entire grain range > 20 mm by return and/or manual sorting in coarse grain > 220 mm
- Material solution with sufficient retention time
- Separation of insoluble components by classification

In Germany, paper and cardboard packaging composites are collected together with lightweight packaging and, during the sorting, are apportioned primarily to the sorting fraction "Paper and cardboard from Lightweight Packaging" (fraction number 550).

When evaluating composite packaging on a paper base, it must be taken into account that the secondary material (for example, the tinplate of a composite can, the aluminum foil of a soup bag, etc.) can be dominant in the sorting process and thus force an allocation to recycling paths meant for other material.

The generation of the fraction "Paper and cardboard from Lightweight Packaging" takes place via NIR separation, so that identifiability in the NIR reflection spectrum is required for a determination via recycling path 11. The recyclable fraction in a more narrow sense is, for this recycling path, the fiber fraction; other components are separated as reject. The treatment is carried out in specialized (certified) waste paper processing lines analogous to recycling path 8, i.e. with significantly longer pulping times than in recycling path 13.
4.2.12 Recycling path 12: Glass

Reference scenario recyclability, glass (dated 02/2013)

Collection

Sorting

classification

crushing

windsifting

magnetic separation

eddy-current separation, induction separation

optical sorting

optical color sorting

ferrous metals

non-ferrous metals

residue

recyclate, sorted by size and color

Process steps, specific with no relevance

Process steps to be considered in individual cases

Process steps, significant
Collection structures for glass can be assumed in the following countries without further assessment:

- European Union
- Switzerland

Glass is typically collected separately as a mono-flow and processed further in specialized plants.

The block flow diagram in the following figure illustrates schematically the process of a state-of-the-art glass recycling plant. The figure also gives what products can result from such a plant. The exact characterizations and descriptions can be found in the guideline "Quality requirements for glass fragments for use in the glass-container industry" (T120).

Today's existing facilities have only partially incorporated all of the elements necessary to make them state-of-the-art. In the basic procedure, however, standardisation has been reached. This results from the fact that the nationwide collection scheme for glass is largely uniform, and uniform requirements are also placed on the sorted products.
4. Appendices

Figure 4: Schematic representation of a state-of-the-art recovered glass processing plant
During plant operating times, both the intermediate storage and the feeding of material into the process are carried out mainly by means of wheel loaders. An even volume flow is decisive for optimum function of the downstream process stages. Therefore, the feeding of the plant takes place via a dosing feeder.

Many processing plants initially carry the input mass flow via a small sorting cabin with one or two sorting workstations. If necessary, coarse impurities materials can be removed from the material flow before the first process stage. This generally serves to protect the subsequent aggregates.

In order to achieve a more uniform grain size distribution, the material stream is ground to a grain size of 10 to 60 mm. Current standards call for impact mills and roll crushers to be used for this purpose. It is important that as little fine grain as possible is produced during the grinding process, since an excessively fine fraction of grain adversely affects subsequent sorting stages.

When choosing the crushing unit, it is also important to ensure that the thick bottoms and necks of bottles, such as those with cork stoppers, are crushed reliably to flat glass shards in order to achieve an optimum size for subsequent process steps.

In general, a second grinding stage is used after a grading of the material flow has taken place. The coarse grain > 60 mm is also ground by means of impact mills or roll crushers and then fed to a new grading stage.

For the separation of all ferromagnetic materials (mainly caps made of tinplate), suspension magnets are used. These separators are installed in a transfer point and the feed belt is designed to be regulated and fast-running in order to minimize misplaced material resulting from the overlapping of particular items. Splitters are designed as rollers that rotate against the conveying direction. In this way, the purity of the metal product can be optimized and clogging can be avoided.

Glass fragments often have a high proportion of labels and coating residues made of paper, metal and plastics. In the optical sorting stage, this can lead to false sorted material, which can then reduce the quality of the final product and cause a loss of glass product.

In label removers, wear-resistant conveyor paddles create a compressed but gentle friction between the glass shards. Speed-regulated drives, adjustable conveying slopes, and conveyor lengths can be used to optimize operating times and thus ensure the full abrasion of unwanted coatings.

Paper fibers, plastic foil, dried food residues and similar light impurities not only reduce the product quality, but also interfere with subsequent sorting stages. In order to remove these contaminants from the material flow, direct or cross-flow wind sifters are used.
The grain size range is the deciding factor for sorting results in subsequent sorting stages. The material flow is divided into different grain size ranges by means of vibration or flip-flow screens. Generally, several screens are installed one behind the other.

An initial screen separation stage is a proven first step, and causes the material flow to be graded into the grain size fractions 0 mm to 15 mm, 15 mm to 60 mm and > 60 mm. The fraction 0 mm to 15 mm is then subdivided once again into the grain size fractions 0 mm to 3 mm and 3 mm to 15 mm.

All grain size fractions are separately fed to a further grading step before the subsequent optical sorting. The remaining fine grain < 3 mm is then screened out, as it can significantly interfere with the sensitive sensor-based sorting steps.

The coarse grain > 60 mm is often passed through a sorting cabin after the first screening stage. Any remaining extraneous material can then be sorted out of the material flow by hand. Although this sorting station is installed in most state-of-the-art plants, it is usually occupied only when required.

Non-ferromagnetic separators are used for the separation of metallic, non-ferromagnetic components since these can cause undesired discoloration in glass production and can adversely affect quality. Eddy current separation is generally used for the separation of non-ferrous metals.

In addition to eddy current separators, sensor-based sorting units are also used during glass separation for the separating out of non-ferrous metals from the material flow. These units are capable of recognizing metal objects in the material flow starting from a size of 1 mm and, once identified, separate these items by compressed air from the material flow.

For the sorting of shards by color, but also for the sorting of contaminants and heat-resistant glass, ceramics and glass with a high heavy metal content (e.g., lead glass), sensor-assisted sorting units are used in all state-of-the-art systems. In the ultraviolet and visible wavelength range of the light, these detect each shard in the material flow, which is led past detector units along a conveyor trough. The heat-resistant and lead-containing glass is identified by UV sensors and RGB camera systems or X-ray detectors. Within milliseconds, all detected information is evaluated so that, at the end of the conveyor trough, pressure air sensors can clear the identified extraneous material with a jet of air.

Stringent requirements are placed on glass as secondary feedstock, and so regular quality control in modern processing plants is now a necessary part of any state-of-the-art system. Sample quantities for testing can be taken manually. Automatic systems extract, weigh, archive, and
evaluate collected data from all process steps independently, thus enabling continuous system and quality monitoring.

The processed shards are delivered to glass works, where remelting to new container glass takes place. The metal fractions obtained are fed into the metal recycling process. Other separated impurities including special-purpose glass are currently not recycled.

To assess recyclability, the following process technology is usually required:

- High-resolution color detection for glass and ceramics, stone and porcelain with a grain size > 2 mm
4.2.13 Recycling path 13: Paper, cardboard

Reference scenario recyclability, paper and cardboard (dated 02/2013)

Collection

Sorting

Magnetic separation

Mechanical board separation

NIR impurities

Manual product control

Reprocessing

Fiber treatment

Pulper

1.04  1.02  1.11

Ferrous metals

Residue

Container/curb side collection/bring-system

Classification

Classification

Coarse

Fines

Process steps, specific with no relevance

Process steps to be considered in individual cases

Process steps, significant

Rejects

Recyclate
Collection structures for paper cardboard are already available in the following countries:

- European Union
- Switzerland

Paper and cardboard are usually collected as a mono-flow separately from other materials. The exception is in France, where packaging paper is collected in a mixed system (with cans and plastic packaging).

The following figure illustrates schematically the process of a state-of-the-art paper sorting system.

![Diagram](image.png)

**Figure 5: Schematic illustration of a state-of-the-art paper/cardboard sorting system**

The figure also shows the common products of a waste paper sorting system. The exact characterizations and descriptions can be found in the "European list of standard grades of paper and board for recycling" (DIN EN 643).
During plant operation, both intermediate storage and the loading of material into the system is carried out by means of wheel loaders. An even volume flow is crucial for optimal utilization of the subsequent process stages. Therefore, the feeding of input material into the system is generally carried out by a dosing feeder, which also slightly loosens the waste paper.

Various types of flat sieves are used in paper sorting systems. Disc screens, star screens, flat screens, roller screens and ballistic separators have proven their worth for these types of applications.

In the initial grading stage, the material flow is divided with a flat sieve. The oversized grain (> 150 mm) made up mainly of large cardboard is fed to a further grading stage with a large screen mesh size. In the overflow, the large (> approx. 300 mm) and stiff cardboard (1.04: corrugated paper and board packaging) are sorted out. This fraction is subsequently placed in a hopper and pressed into bales before loading.

The smaller-sized grain (<150 mm) is also fed into another stage following the first grading stage in order to separate the grain fraction < 60 mm. This material flow (1.02: mixed papers and boards) consists predominantly of smaller paper and cardboard fragments of different paper grades, but also slightly from minor contaminants, such as, for example, glass flakes, paper clips, stones, corks and dust. This fraction can neither be sorted manually nor by means of optical sorting stages and degrades the desired quality of the final product of the deinking material. This product fraction (1.02) is also generally compressed after an intermediate storage stage in a hopper or box before loading.

After the grading stages, the material flows of 150 mm to 300 mm and 60 mm to 150 mm are fed in parallel to further process steps. The separating sections of the grading stages and the number of subsequent parallel sorting lines depend on the capacity of the overall system.

In order to remove the cardboard and cartons still contained in the two material flows, so-called cardboard spikes are used. Paper and cardboard is impaled on belts embedded with nails. Flexible paper is not caught by the nails. At the end of the conveyor belt, the impaled cardboard and cartons are loosened and taken separately from the main paper flow.

The sorted cardboard and cartons are fed either to the corrugated paper and board packaging fraction (1.04) or the mixed papers and boards fraction (1.02).

The material flow of both processing lines which have now been largely freed from cardboard and cartons is then purged of further quality-reducing contaminants by means of sensor-assisted sorting units. The material flow is optimally distributed and separated on the acceleration belts so that the sensor units can detect the near-infrared and visible light wavelength range of each object.
Instantly, the detector unit evaluates the information and passes the command to further separate the localized unwanted components and contaminants from the material flow by means of precise compressed air bursts at the end of the conveyor belt. This separated fraction is also fed to the mixed papers and boards fraction (1.02).

The subsequent material flows are transported to a sorting cabin for quality control. Here, unwanted paper and cardboard components, papers of poor quality, dyed papers, as well as impurities of all kinds can be sorted out. The separated components are either fed to the mixed papers and boards fraction (1.02) or to a separate contaminant/rejects container.

After inspection by the sorting staff, there is left only a high-quality deinking waste paper grade (1.11: sorted graphic paper for deinking) on the conveyor belts. This is stored in hoppers or boxes and generally compressed before loading. Loose loading is also possible.

The individual varieties are sold to paper factories in which wet treatment is carried out. In contrast to recycling path 8, for varieties made from mixed waste paper, pulping is carried out with clearly lower processing times so that heavy-suspended or wet-strength materials are rejected from the fraction.

For France, it should be noted that for the processing of the packaging fraction sorted from the mixed collection, longer pulping times (15 min.) are applied.

To assess recyclability, the following process technology is usually required:

- Mechanic cardboard separation
- Automatic sorting of contaminants
- Manual sorting of contaminants
- Material dissolving solution with sufficient dwell time (mixed paper and boards, type 1.02)
- Separation of insoluble components by classification
4.3 Appendix 3: Basic data form

Address
(for certificate)

Article designation:

Article no.:

1. Basic components

What specific basic components is the product made of (e.g. thermoformed tray and sealing foil or cup, sealing foil and cover)?

<table>
<thead>
<tr>
<th>Basic component</th>
<th>Description</th>
<th>Individual weight in g or relative proportion of the entire product in %</th>
<th>Special features:</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0 (example)</td>
<td>Thermoformed tray</td>
<td>23 g (78%)</td>
<td>-</td>
</tr>
<tr>
<td>C0 (example)</td>
<td>Cap, Lid</td>
<td>8 g (22%)</td>
<td>filled (chalk)</td>
</tr>
<tr>
<td>C1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td></td>
<td></td>
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<tr>
<td>C3</td>
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<td></td>
<td></td>
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<tr>
<td>C4</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
## 2. Materials and substances

What individual components do the specific basic components consist of (specification of all layers including coupling agent, adhesive, paint, coating, printing, etc. For plastics, please specify the precise type, e.g., PET-A, PE-HD, etc.). For adhesive, additives, printing colors etc., please enclose the safety data sheets.

<table>
<thead>
<tr>
<th>Layer / subcomponent</th>
<th>Proportion of the basic component (please complete at least 2 of the 3 columns)</th>
<th>Special features (for adhesives, please specify information on water-solubility)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material / substance specification</td>
<td>Weight or surface weight</td>
<td>Density</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1 PE</td>
<td>20.0 g</td>
<td></td>
</tr>
<tr>
<td>2 Coupling agent</td>
<td>2.0 g</td>
<td></td>
</tr>
<tr>
<td>3 EVOH</td>
<td>4.8 g</td>
<td></td>
</tr>
<tr>
<td>4 Coupling agent</td>
<td>2.0 g</td>
<td></td>
</tr>
<tr>
<td>5 PE</td>
<td>22.0 g</td>
<td></td>
</tr>
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<td>6</td>
<td></td>
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<td>10</td>
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</table>

<table>
<thead>
<tr>
<th>Layer / subcomponent</th>
<th>Proportion of the basic component (please complete at least 2 of the 3 columns)</th>
<th>Special features (for adhesives, please specify information on water-solubility)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material / substance specification</td>
<td>Weight or surface weight</td>
<td>Density</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1 PET</td>
<td>12.0 g / m²</td>
<td></td>
</tr>
<tr>
<td>2 Printing color</td>
<td>1.0 g / m²</td>
<td></td>
</tr>
<tr>
<td>3 Adhesive</td>
<td>3.0 g / m²</td>
<td></td>
</tr>
<tr>
<td>4 Aluminium</td>
<td>20.0 g / m²</td>
<td></td>
</tr>
<tr>
<td>5 Adhesive</td>
<td>3.0 g / m²</td>
<td></td>
</tr>
<tr>
<td>6 Print</td>
<td>0.02 g / m²</td>
<td></td>
</tr>
<tr>
<td>7 PP</td>
<td>45.0 g / m²</td>
<td></td>
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<tr>
<td>8</td>
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<tr>
<td>9</td>
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</tbody>
</table>
### 4. Appendices

<table>
<thead>
<tr>
<th>C1</th>
<th>Layer / subcomponent</th>
<th>Proportion of the basic component (please complete at least 2 of the 3 columns)</th>
<th>Special features (for adhesives, please specify information on water-solubility)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Material / substance specification</td>
<td>Weight or surface weight</td>
<td>Density</td>
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<th>Layer / subcomponent</th>
<th>Proportion of the basic component (please complete at least 2 of the 3 columns)</th>
<th>Special features (for adhesives, please specify information on water-solubility)</th>
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## 4. Appendices

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</table>
3. Connections of basic components

<table>
<thead>
<tr>
<th>Basic component no.</th>
<th>Type of connection (mechanical, fully glued, selectively glued, cladding, laminated, etc.)</th>
<th>For adhesives: Water-soluble?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>Selectively glued</td>
<td>No</td>
</tr>
<tr>
<td>2 and 3</td>
<td>Mechanical, dispersible</td>
<td></td>
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</tbody>
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4. Paper and cardboard containing packaging

Are water-resistant paper cardboard parts included?
If yes, in which subcomponents / layers?

_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________

5. Printing colors

Are printing colors or raw materials of the EuPIA exclusion list applied?
If yes, in which basic components?

_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________
4. Appendices

6. Additives, fillings, barrier layers

If not already provided under no. 2, specify in the following information on additives and barrier layers with reference to the individual components, if applicable.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Samples

☐ The following number of product samples in enclosed (usually 10) ______

Safety data sheets for the following materials, components enclosed / are subsequently provided

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Contact

If you have questions or require additional information, please contact
Name: ________________________________
Contact information: ________________________________
________________________________________________________________________
________________________________________________________________________
4.4 Appendix 4: Certificate template

CERTIFICATE

Recyclability of Packaging

PRINCIPAL
Sample Street 1
D-00000 Sampletown

The company receives the certification of recyclability for the following packaging:

Designation

Packaging designation (Article No. XXXXXXX)

Test result

Allocation to path/specification:
- Sample Type A, Fraction No. 000
- Sample Type B, Fraction No. 001

Recycling path:
- Sample Type A, Fraction No. 000
- Sample Type B, Fraction No. 001

Recyclate (final product):
- e.g. XX-regranulate

Test standards/scope of application: Catalogue of requirements and assessment of the institute cyclos-HTP (state of XXX.XXX.XXX)

In accordance with the test results and the examination document the recyclable percentage of the packaging amounts to:

XX %

This certificate (No. XXX) is valid until the XX.XX.XXX (2 years upon issue). The certificate will lose its validity in case of qualitative or quantitative changes of packaging components.

Place, the XX.XX.XXXX

Institute cyclos / HTP

This certificate (No. XXX) is only valid in conjunction with 3 pages of the related assessment report.