Circ Pack
Summary of results

• Increasing the circularity of high barrier flexible plastic packaging
Multilayer laminate packages increase shelf life for food and is in many cases necessary for safe packaging.

**MULTI** material laminate (MML)
- PE
- PA
- PE

**MONO** material laminate (MOL)
- PE
- EvOH
- PE

Different polymers in the layers
- Mostly regarded as **NOT** Recyclable

Very thin barrier between mono polymer layers
- Limited knowledge about recyclability
Circ Pack

Effect of project

Study the recyclability of high barrier flexible plastic packaging with the potential to increase the sorting and recycling rates for plastic packages with 10%

Objective of project

Focus on studying mono laminate films specifically the influence of adhesives and barriers
WP 1 Market analysis
WP 1: Market analysis

The overall aim of WP 1 was to conduct an initial market analysis to map and quantify the current and future use of complex high barrier MMLs and MoLs on the Swedish market.

Based on the market analysis, suggestions of suitable MoLs were made to be tested in WP 2 and WP 3.

Project partners:
- **Brand owners**: Orkla Foods Sverige, Håska, DAGAB, ICA, Stello, Arla
- **Material & Packaging producers**: Graphic Packaging International, Mondi, Eval, Henkel
- **Collection, sorting & recycling**: Svenskt plaståtervinnning, Tomra, Fti, Graf, Näringslivets produktcentrum, Pre One
- **Research Institutes**: RISE, IVL, Swedish Environmental Research Institute
Current situation: Common aspects of flexible food packaging

MoLs of both PE and PP are available on the market
- Number of layers varies depending on the product
- Thickness varies depending on product (around 30-100 micron)
- E.g. PUR-based adhesives are used (thickness around 1-2 micron)
- About 5% EVOH is common (thickness around 1-3 micron)
- EVOH is the main barrier utilised in flexible food packaging. Other barriers that are relevant for this project are metallisation, SiOx and AlOx (very thin barriers ~Angstrom range)
Current situation: *Use of flexible food packaging in Sweden (2020)*

Data from SPR and one of the brand owners, as well as numbers from the report *Mapping of plastic flows in Sweden 2020: With regard to raw materials, products and waste.*

- 46% of the 131 800 tonnes of consumer plastic packaging put on the Swedish market is assumed to be flexible packaging
- 61% of the flexible consumer packaging is assumed to be used for convenience/grocery goods
- 39% of the flexible convenience/grocery packaging is assumed to consist of MMLs and 61% MoLs and mono films

![Pie chart showing share of consumer goods in flexible packaging market in Sweden 2022](image_url)

- 22% Speciality/shopping goods
- 17% MMLS in convenience/grocery goods
- 24% Mono films and MoLs in convenience/grocery goods
- 37% Other
Current situation: Sorting and recycling of plastic packaging

Sorting is affected by, for example:

- Non detectable materials by NIR-technology, such as packaging coloured with carbon black
- The size, shape and weight
- The thickness of the outer layer
- Requires specific dataset/spectra for each material to enable sorting

Recycling is affected by, for example:

- Fillers, inks, other materials (incl. barriers) such as plastics, metals and paper
- Type of inks used (e.g. nitrous cellulose binder)
- Adhesives, only limited knowledge of the impact
Future trends

‘Food safety and functionality of the material will always be the main concerns when designing food packaging’- Brand owners

Future trends of high barrier flexible packaging

- Increased use of flexible food packaging
- Increased use of PP
- Increased use of biobased alternatives
- Increased focus on recyclability
- Down gauging
- Mixed materials (e.g. plastic and paper)
- Innovation and new solutions

- Functionality of the material
- Food safety, shelf life and production rate
- Currently used machinery
- Time consuming and costly
**Suggested plastic films to be tested in WP 2 and WP 3**

2. Co-extruded: PE/EVOH/PE  
3. Co-extruded: PP/EVOH/PP  
4. Laminate: BOPE/Adh/PE/EVOH/PE  
5. Laminate: OPP/Adh/PP/EVOH/PP  
6. Laminate: Metallised OPP

**Additional films**

i. Laminate: BOPE/Adh/PE  
ii. Laminate: OPP/Adh/PP  
iii. A film with SiOx or AlOx
WP 2 Sorting
**WP2: Sorting**

The aim of WP 2 was to test how MoL films (PE and PP based) were sorted with existing sorting NIR sensors and current settings in Swedish Plastic Recycling test facility.

Tomra provided necessary spectra interpretations with the help from their test center in Germany.

The outcomes of the sorting tests were suggestions of new settings to increase sensitivity of specific MoL films.

Tomra also assisted Swedish Plastic Recycling in optimization of the sorting programs of the sorting facility to sort the MoL films into desired sorting streams in the new facility (Site Zero) that was commissioned in 2023.
Test materials

<table>
<thead>
<tr>
<th>Main polymer</th>
<th>Sample amount</th>
<th>Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene</td>
<td>15</td>
<td>2 Mono-PE&lt;br&gt;5 PE-EVOH&lt;br&gt;2 PE-Adhesive laminated&lt;br&gt;6 PE-EVOH-Adhesive laminated</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>25</td>
<td>2 Mono-PP&lt;br&gt;9 PP-EVOH&lt;br&gt;1 PP-Adhesive laminated&lt;br&gt;6 PP-EVOH-Adhesive laminated&lt;br&gt;3 PP-Alox-Adhesive laminated&lt;br&gt;4 PP-Metallized-Adhesive laminated</td>
</tr>
</tbody>
</table>
Summary of test results for **PE films** at Swedish Plastic Recycling and Tomra Test Centre

**Object processing**
- Some of the thin films (around 50 µm) difficult to detect if not folded in several layers
- All are detected as LDPE, but the classifier cannot distinguish multilayered PE with other polymers

**Sorting plant simulation**
- All 15 PE - films would most likely be ejected in PE-film fraction with the existing sorting programs
- One of the films (PE-EVOH-adhesive laminated) could potentially contaminate PP-film fraction
- Simulation of sorting PE-multilayered materials need to be done again (improve selectivity parameters in tests)
Summary of test results for PP films at Swedish Plastic Recycling and Tomra Test Centre

Object processing
- All thin films (60 µm and less) difficult to detect if not folded in several layers
- Thick films (150 µm and more) detected as rigid PP
- Films (100 – 150 µm) some detected as rigid PP
- Films (60 – 100 µm) detected as PP film
- Some metallized films problematic to detect

Sorting plant simulation
- No PP film sorting in old sorting plant, but a test with a classifier for rigid PP (can distinguish PP film) show majority can be detected as PP film
- None of the films would be ejected in LDPE fraction (low risk of cross-contamination in LDPE)
- All films thicker than 100 µm will be ejected in PP rigid fraction if they are not separated as film in ballistic separators and wind sifters (potential contaminations in rigid PP stream)
Example of static tests on films in project, evaluated in Tomra Test Centre

<table>
<thead>
<tr>
<th>Sample no</th>
<th>Sample description</th>
<th>Result with standard waste sorting classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>OPE/PE/EVOH/PE 85 µm</td>
<td>Detected as PE film</td>
</tr>
<tr>
<td>8</td>
<td>OPP/PP/EVOH/PP 61 µm</td>
<td>Detected as PP film and PP rigid</td>
</tr>
<tr>
<td>9</td>
<td>PP/EVOH/PP/PP/EVOH/PP 250 µm</td>
<td>Detected as PP rigid</td>
</tr>
</tbody>
</table>

Figure 6: Classified picture of sample 7-9 by standard database
Summary of sorting tests

Existing waste classifiers (both at Swedish Plastic Recycling and Tomra)

- PE films (mono and MoL)
  - All detected as LDPE
  - Will most likely be sorted as PE film in existing sorting plants

- PP films (mono and MoL)
  - Detected as PP rigid with thicker materials (>100 µm)
  - Very thin materials (20-30 µm) and metallized films difficult to detect
  - Thin materials (50-100 µm) difficult to distinguish between PP film and PP rigid
  - Sorting behaviours difficult to predict in existing sorting plants – risks of film contaminations in rigid PP

Limitations with current tests

- New films, not post consumer waste

- Thin films difficult to detect, folded materials better detection (more similar to final packaging formats like bags and flowpacks)

- Folded films (e.g. in a packaging format and waste material) can result in different NIR spectra, which may influence the sorting behaviors – especially for multilayered thin materials
Summary of sorting tests

Test conditions

Post consumer packaging waste sorting
Recent developments in sorting of flexible plastic packaging in Sweden

**Site Zero**

- Swedish Plastic Recycling commissioned the new sorting center Site Zero in 2023
- It has capacity to sort all collected household plastic packaging waste in Sweden into 12 recyclable plastic fractions, including two mono-film fractions (LDPE and PP film) which can both be mechanically recycled
WP 3 Recyclability

MoL films tested in the project were provided by the film suppliers. The project involved various adhesives and barrier products from diverse suppliers.
What influences the results when testing the recycled film?

- Composition of original film:
  - PP/PE quality of MoL film
  - Adhesive: type and amount
  - Barrier – type and amount
  - Processing conditions
    - Results should only be compared to a reference prepared at the same occasion
What is to be regarded as recyclable?

Criterias

- visual inspection of transparent films
  - Increased haze, presence of gels & specks decrease the film quality
- < 25% decrease of the mechanical properties compared to virgin reference

ISO 6383-2 Tear Strength
ISO 527-3 Tensile Stress and elongation at break
ISO 7765 Dart Impact
Visual evaluation- Haze, Gels & Specks
PE Film blowing at Norner

Films were blown on a Collin pilotline:
- extruder:
  - 25 mm screw
  - L/D: 25
- Output: 1-8 kg/h
- Nozzle diameter: 50mm
- Gap: 1,5mm
- ”inflation ratio” BUR: 1:3
- 70 rpm
- Film thickness: 35µm
<table>
<thead>
<tr>
<th>ID</th>
<th>Film content</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-1</td>
<td>PE / EVOH / PE / EVOH / PE</td>
</tr>
<tr>
<td>PE-2</td>
<td>BOPE / ADH / PE / EVOH / PE</td>
</tr>
<tr>
<td>PE-3</td>
<td>OPE / PE / EVOH / PE</td>
</tr>
</tbody>
</table>

Strange smell

*Not further evaluated!*
<table>
<thead>
<tr>
<th>ID</th>
<th>Film content</th>
<th>Thickness (µm)</th>
<th>EvOH (%)</th>
<th>ADH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE 1</td>
<td>PE / EVOH / PE / EVOH / PE</td>
<td>200</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>PE 3</td>
<td>OPE / PE / EVOH / PE</td>
<td>85</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>PE 4</td>
<td>MOPE / ADH / PE (white)</td>
<td>~100</td>
<td></td>
<td>same ADH as PE5; 3.7%</td>
</tr>
<tr>
<td>PE 5</td>
<td>MOPE / ADH / PE-EVOH (white)</td>
<td>~100</td>
<td></td>
<td>Same ADH as PE4; 3.7%</td>
</tr>
<tr>
<td>PE 6</td>
<td>MOPE / ADH / PE</td>
<td>70</td>
<td></td>
<td>ADH: 3.8g/m²</td>
</tr>
<tr>
<td>PE 7</td>
<td>OPE / ADH / PE / EVOH / PE</td>
<td>66</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>PE 8</td>
<td>PE / ADH / PE</td>
<td>~100</td>
<td></td>
<td>ADH: 1.5g/m²</td>
</tr>
<tr>
<td>FT 5230</td>
<td>Ref PE, FT 5230</td>
<td>Pellets</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Photos of PE films

REF  PE1  PE3  PE4  PE5  PE6  PE7  PE8
<table>
<thead>
<tr>
<th>ID</th>
<th>Film content</th>
<th>EvOH (%)</th>
<th>Visual evaluation (gels and specks, surface appearance)</th>
<th>Tear</th>
<th>Tensile (stress)</th>
<th>Tensile (Elongation)</th>
<th>Dart drop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MD</td>
<td>TD</td>
<td>MD</td>
</tr>
<tr>
<td>PE 1</td>
<td>PE / EVOH / PE / EVOH / PE</td>
<td>3,8</td>
<td>White pigment</td>
<td>Less than 25% lower compared to ref. value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE 3</td>
<td>OPE / PE / EVOH / PE</td>
<td>5</td>
<td></td>
<td>Failed: More than 25% lower compared to ref. value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE 4</td>
<td>MOPE / ADH / PE (white)</td>
<td>Same ADH as PE5; 3,7</td>
<td>White pigment</td>
<td>Failed: More than 25% lower compared to ref. value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE 5</td>
<td>MOPE / ADH / PE-EVOH (white)</td>
<td>Same ADH as PE4; 3,7</td>
<td>White pigment</td>
<td>Failed: More than 25% lower compared to ref. value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE 6</td>
<td>MOPE / ADH / PE</td>
<td>ADH: 3,8g/m²</td>
<td>Gels and specks</td>
<td>Passed: Less than 25% lower compared to ref. value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE 7</td>
<td>OPE / ADH / PE / EVOH / PE</td>
<td>5</td>
<td>Gels and specks</td>
<td>Passed: Less than 25% lower compared to ref. value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE 8</td>
<td>PE / ADH / PE</td>
<td>ADH: 1,5g/m²</td>
<td>Some gels</td>
<td>Passed: Less than 25% lower compared to ref. value</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PP films
## PP samples for extrusion *no adh*

<table>
<thead>
<tr>
<th>ID</th>
<th>Film content</th>
<th>Thickness (µm)</th>
<th>EvOH (%)</th>
<th>ADH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP 1</td>
<td>BOPP / ADH / PPxx AND EVOH</td>
<td>52</td>
<td>5,7</td>
<td></td>
</tr>
<tr>
<td>PP 2*</td>
<td>PP / EVOH / PP</td>
<td>300</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PP 4*</td>
<td>CPP / (PP / EVOH / PP) / (PP / EVOH / PP)</td>
<td>216</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>PP 5</td>
<td>OPP/ADH/PP-EVOH-PP</td>
<td>61</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>PP 6*</td>
<td>(PP/EVOH/PP)*2 (plug)</td>
<td>250</td>
<td>4,2</td>
<td></td>
</tr>
<tr>
<td>PP 7*</td>
<td>(PP/EVOH/PP)*2 (tray)</td>
<td>350</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MPP 1</td>
<td>OPP/ADH/MOPP</td>
<td>45</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PP 5r low</td>
<td>OPP/ADH(^1)/PP-EVOH-PP</td>
<td>~61</td>
<td>5</td>
<td>Adh:1,3 g/m(^2)</td>
</tr>
<tr>
<td>PP 5r high</td>
<td>OPP/ADH(^1)/PP-EVOH-PP</td>
<td>~61</td>
<td>5</td>
<td>Adh:1,9 g/m(^2)</td>
</tr>
<tr>
<td>PP 8</td>
<td>BOPP/ADH/PP/EVOH/PP</td>
<td>62</td>
<td>5,15</td>
<td></td>
</tr>
<tr>
<td>Ref PP: BC918 CF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Potentially recyclable adhesive*
PP film casting at Norner

- Plastik Maschinenbau cast film pilotline
- Extruder: 30mm screw diam
- L/D: 25
- Output: 5-20kg/h
- Nozzle width: 400 mm
- Nozzle width: 0,1-2,0mm
- Water cooling for rolls
- 2 cooling rolls 150mm diameter

Comment:
It was difficult to get a stable extrusion at 35μm, so the thickness was increased to 45-50μm. The line was run at 15rpm to have control with such a thin film.
From 230120

<table>
<thead>
<tr>
<th>ID</th>
<th>Film content</th>
<th>EvOH (%)</th>
<th>Visual evaluation (gels and specks, surface appearance)</th>
<th>Tear</th>
<th>Tensile (stress)</th>
<th>Tensile (Elongation)</th>
<th>Dart drop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td>MD</td>
<td>TD</td>
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<td></td>
<td></td>
<td>MD</td>
<td>TD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 1</td>
<td>BOPP / ADH / PPxx</td>
<td>5,7</td>
<td>Gels and specks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 2</td>
<td>PP / EVOH / PP</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 4</td>
<td>CPP / (PP / EVOH / PP) / (PP / EVOH / PP)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 5</td>
<td>OPP / ADH / PP-EVOH-PP</td>
<td>5</td>
<td>Gels and specks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 6</td>
<td>(PP / EVOH / PP)*2 (plug)</td>
<td>4,2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 7</td>
<td>(PP / EVOH / PP)*2 (tray)</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPP 1</td>
<td>OPP / ADH / MOPP</td>
<td>0</td>
<td>Dark color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Passed: Less then 25% lower compared to ref. value
Failed: More then 25% lower compared to ref. value
<table>
<thead>
<tr>
<th>ID</th>
<th>Film content</th>
<th>EvOH (%)</th>
<th>Visual evaluation (gels and specks, surface appearance)</th>
<th>Tear</th>
<th>Tensile (stress)</th>
<th>Tensile (Elongation)</th>
<th>Dart drop</th>
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<td>MD</td>
<td>TD</td>
<td>MD</td>
<td>TD</td>
</tr>
<tr>
<td>PP 2</td>
<td>PP / EVOH / PP</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 6</td>
<td>(PP/EVOH/PP)*2 (plug)</td>
<td>4,2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 7</td>
<td>(PP/EVOH/PP)*2 (tray)</td>
<td>3</td>
<td>Some gels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP 5r-high</td>
<td>OPP/ADH/PP-EVOH-PP</td>
<td>5</td>
<td>Rough surface, gels and specks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADH: 1,9 g/m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP5r-low</td>
<td>OPP/ADH/PP-EVOH-PP</td>
<td>5</td>
<td>Rough surface, gels and specks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADH: 1,3 g/m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP8</td>
<td>BOPP/ADH/PP/EVOH/PP</td>
<td>5,15</td>
<td>Some gels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADH: 3,5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Passed:** Less than 25% lower compared to ref. value  
**Failed:** More than 25% lower compared to ref. value
Conclusions

• Mono-laminate films can be considered recyclable if a suitable type and combination of adhesive and barrier are used. Each combination must be individually tested.
• PE laminates have in this study demonstrated generally better recyclability than PP laminates
• Up to 5wt % EvOH have low impact on recyclability (without adhesive present)
• Adhesives might have a negative effect on recyclability, including color, odor and mechanical properties.
• rPP from films can be recycled with rigid PP grades, thus expanding the applications for example to injection molded items
WP 4 Recycling Manual
The responsibility for collecting packaging is transferred to municipalities

The overall aim of WP 4 is to update the Design for Recycling guidelines developed by FTI/NPA in regards of laminate films. In addition, the extended producer responsibility fee will be monitored and possibly changed.

FTI's expertise is transferred to Näringslivets Producentansvar
Examples of Design for Recycling guidelines

There are various Design for Recycling guidelines available today. The guidelines are intended to support the industry on how to improve overall recyclability of flexible plastic laminates in regards to mechanical recycling.

<table>
<thead>
<tr>
<th>Example of Design for Recycling Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>National</strong></td>
</tr>
<tr>
<td>• FTI/NPA</td>
</tr>
<tr>
<td>• Der Grune Punkt</td>
</tr>
<tr>
<td>• Netherlands Institute for Sustainable Packaging (KIDV)</td>
</tr>
<tr>
<td>• COTREP</td>
</tr>
<tr>
<td>• Fost Plus</td>
</tr>
<tr>
<td><strong>European/UK</strong></td>
</tr>
<tr>
<td>• RecyClass</td>
</tr>
<tr>
<td>• CEFLEX</td>
</tr>
<tr>
<td>• RECOUP (UK)</td>
</tr>
<tr>
<td><strong>International</strong></td>
</tr>
<tr>
<td>• Efficient Consumer Response (ECR)</td>
</tr>
<tr>
<td>• APR</td>
</tr>
</tbody>
</table>
Criteria for Design for Recycling

When evaluating the recyclability of flexible PE and PP films, a number of different criteria are widely used. The criteria used for flexible PE and PP packaging are, for example:

- Material structure
- Additives, fillers and density
- Barriers
- Size and shape
- Adhesive
- Pigments and colour
- Printing and varnish
- Labelling

The recyclability is often evaluated based on a traffic lights system:

- Full compatibility
- Limited compatibility
- Low compatibility
## Comparison of Criteria: Material structure

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Full compatibility</th>
<th>Limited compatibility</th>
<th>Low compatibility</th>
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</thead>
<tbody>
<tr>
<td><strong>Poly ethylene (PE)</strong></td>
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</table>
| FTI/NPA | PE (LDPE, LLDPE, HDPE) ≥ 90% | PE ≥ 70% | PE ≤ 70%  
PE/PP with PP ≤ 5%  
Other polymers (e.g. PET, PVC) |
| RecyClass | PE (PE-LD, PE-LLD, PE-HD) ≥ 90% | PE ≥ 70% | 30% ≤ PE ≤ 70%  
PE/PP with PP > 5%  
Other polymers (e.g. PET, PVC) |
| CEFLEX | PE ≥ 90% | PE ≥ 80% | PE ≤ 80% |
| **Poly propylene (PP)** | | | |
| FTI/NPA | PP ≥ 90% | PP ≥ 70%  
PP/PE with PE ≤ 10% | PP ≤ 70%  
PP/PE with PE > 10%  
Other polymers (e.g. PET, PVC) |
| RecyClass | PP ≥ 90% | PP ≥ 70% | 30% ≤ PE ≤ 70%  
Any other polymer (e.g. PET, PVC) |
| CEFLEX | PP ≥ 90% | PP ≥ 80% | PP ≤ 80% |
## Comparison of Criteria: Barriers

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</table>
| FTI/NPA | SiOx or AlOx, without additional coating | • EVOH ≤ 5%  
• PVOH ≤ 1%  
• PA 6/66 copolymer ≤ 15%  
• Metallisation | • EVOH > 5%  
• PVOH > 1%  
• Other types of PA, PVC, PVDC, aluminium foil |
| RecyClass | SiOx and AlOx without additional coatings | • EVOH ≤ 5%  
• PA 6/66 copolymer ≤ 15% | • EVOH > 5%  
• Other type of PA, PVOH, PVC, PVDC  
• Metallisation and aluminium foil |
| CEFLEX | Barrier and coating ≤ 5% including AlOx, SiOx, EVOH, PVOH, Acrylic, metallisation | Barrier and coating > 5% including AlOx, SiOx, EVOH, PVOH, Acrylic | To be determined |
| **Poly propylene (PP)** | | | |
| FTI/NPA | SiOx or AlOx, without additional coating | • EVOH ≤ 5%  
• Metallisation | • EVOH > 5%  
• PA, PVC, PVDC, aluminium foil |
| RecyClass | SiOx and AlOx without additional coatings | • EVOH ≤ 5%  
• Metallisation | • EVOH > 5%  
• PVC, PVDC and PA, aluminium foil |
| CEFLEX | Barrier and coating ≤ 5% including AlOx, SiOx, EVOH, PVOH, Acrylic, metallisation | Barrier and coating > 5% including AlOx, SiOx, EVOH, PVOH, Acrylic | To be determined |
## Comparison of Criteria: Adhesives

<table>
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<th>Limited compatibility</th>
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| FTI/NPA | • Aliphatic polyurethane-based adhesive < 2.5%, provided it is not under the red column  
• Adhesive approved with full compatibility by RecyClass | • Polyurethane-based (aliphatic or aromatic) or water-based acrylate adhesive ≤ 5%  
• Adhesive approved with limited compatibility by RecyClass | • Adhesives that have not been tested and approved by RecyClass. |
| RecyClass | Laminating adhesives approved as fully compatible by RecyClass | • Aliphatic polyurethanes ≤ 2.5%  
• Laminating adhesives approved as limited compatible by RecyClass | • Aliphatic polyurethanes > 2.5%  
• Aromatic polyurethanes and water-based acrylics or any other laminating adhesives (Epoxy, etc.) |
| CEFLEX | Polyurethane, acrylic or natural rubber latex adhesives, as well as non-PE tie-layers ≤ 5% | Polyurethane, acrylic or natural rubber latex adhesives, as well as non-PE tie-layers ≥ 5% | To be determined |

| **Poly propylene (PP)** | | | |
| FTI/NPA | Same as RecyClass, see below.  
Same as RecyClass, see below.  
Same as RecyClass, see below. | | |
| RecyClass | Laminating adhesives approved as fully compatible by RecyClass | Laminating adhesives approved as limited compatible by RecyClass | Any other laminating adhesives |
| CEFLEX | Polyurethane, acrylic or natural rubber latex adhesives, as well as non-PE tie-layers ≤ 5% | Polyurethane, acrylic or natural rubber latex adhesives, as well as non-PE tie-layers ≥ 5% | To be determined |
Updated manual and fee criteria

- During the autumn of 2022, FTI and Swedish Plastic Recycling took the first step towards a harmonization with RecyClass.

- In January 2023 a new version of the manual was presented (version 6) together with new fee criteria that came into effect April the 1st 2023
  - E.g. increased amount of EVOH allowed for flexible PE packaging

- In June 2023 a new version of the manual was published (version 7)
  - E.g. certain laminating adhesives for flexible PE packaging are approved, added guidelines for flexible PP packaging
WP 5 Demonstration

- Functionality of MoL films including processability
- Preparation of new films based on recycled MoL
MoL processability

PE film denote PE4 was used for the testing

- some temperature adjustments were needed to run MoL in the production equipment
- Bags were formed without problems
- The sealings /welds became tight
- Next step is to test bags being filled with frozen product
Films denoted PP2 as top film and PP7 as tray (from WP3) were used

The packaging were formed well but the trial material is thinner and less rigid than the existing material. Best before date is embossed in the bottom of the pack, and the date was a bit harder to read, probably due to the thickness of the trial film.

The welding temperature was increased to 145°C and then the material was burnt. When testing a thinner version of the bottom film, the welding temperature was lowered to 135°C and the forming temperature to 80°C.

Over all the results were OK for a first trial, but the MoL films are “stretchier”, than the current package solution. The cutting of packages was not complete, creating an “accordion effect”
Film blowing recycled MoL - PE

Virgin material

RISE recycled material (25%) containing white pigment
Film blowing recycled MoL - PE

Photo of films with white pigments taped on a window, seeing through the film. Some specks in the films: increasing with recycled content

- Overall good properties of films with 25 and 50% recycled content
- Possible application: as bags for diapers and other consumer goods (it cannot be recycled into new food packages due to legislation)
Conclusions demonstration

• MoL films show promising results in initial processing tests but detailed testing is necessary for each specific package and the production equipment used.

• Films produced from recycled MoL films (without print) show that they can be used for various applications, new packages is one of them (however NOT food packaging due to legislation).
Questions?

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