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# Plastics Packaging **Recyclability by Design**

An essential guide for all those involved in  
development, design, marketing and procurement



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The information contained in this document is for general guidance only. Any details given are intended as a general recommendation based on the best of our knowledge at the time of publication. It does not necessarily guarantee compliance with the different recycling schemes.

This is by no means a comprehensive list. Users are therefore advised to make their own enquiries to check for specific and up-to-date information.

While every effort has been made to ensure the accuracy of the contents of this publication, Recoup can accept no responsibility or liability for any errors or omissions.

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<sup>1</sup>Recoup is a leading authority on plastics waste management, providing expertise and guidance to a wide range of clients across the plastics supply, use and disposal chain.

Introduction	4
Background to document	4
Document scope	4
Aims	5

Questions and answers	5
■ Is this document relevant to me?	5
■ Why is recycling important?	6
■ Why should I follow the guidelines?	6
■ Are there benefits to me if I follow the guidelines?	6
■ What are you asking me to do?	7
■ Will it cost me money?	7
■ Where can I get more information?	7
■ Conclusion	7

General guidelines	8
■ Introduction	8
■ General principles for container / Components	8
■ Residues	9
■ Composite materials / Barrier layers	9
■ Colour of plastic	9
■ Closures / Closure Liners / Cap Sleeves / Seals	10
■ Labels / Safety seals / Adhesives	10
■ Pigments / Inks	11
■ Other components	11
■ Material identification	12
■ Material specific guidelines	14
■ Markets for recycled plastic	15
■ Integration of environmental and legal aspects into the packaging design process	15

Material specific guidelines for bottles	16
■ PET	16/17
■ Polyethylene	18/10
■ PVC	20
■ Polypropylene	21

Material specific guidelines for mixed plastics	22
■ Further guidelines for mixed plastics	22
■ Rigid mixed packaging	22
● PET	22
● PE Tubs and Dishes	22
● PE Tubes	22
● PP Tubs, Dishes and Trays	23
● PP Tubes	23
● PS Tubs, Dishes and Trays	23
■ Film	23
● Material / Material combinations	23
● Labels	23

Bioplastics	24
■ Recyclability of bioplastics	25
■ Effect of bioplastics in current plastic waste streams	25

List of appendices	26
1. Process to generate document	26
2. Recycling of plastic packaging	27
3. Legislative and Environmental Climate	30
4. Packaging and Packaging Waste Directive (94/62/EC)	32
5. Business case for recycling	36
6. Density range of plastics commonly used in packaging	38
7. Key organisations to contact for further information	39
8. Material Identification	40
9. Integration of environmental aspects into the packaging design process	41
10. Glossary of terms	43
11. References	44
12. Organisations supporting the guidelines	45

List of tables	
1. Explanation of terms / colour coding in material specific guidelines tables	
2. PET bottles material specific guidelines table	
3. HDPE bottles material specific guidelines table	
4. PVC bottles material specific guidelines table	
5. PP bottles material specific guidelines table	
6. PS tubs / dishes / trays material specific guidelines table	
7. Composition of Steering Group	
8. Polymer densities and behaviour during sink / float tank separation	
9. Extract from European Commission Material Identification system	
10. SPI Material Identification system	

List of figures	
1. Diagram indicating type of bioplastics of particular relevance to recyclability considerations.	
2. Typical steps in the mechanical recycling of plastic	
3. Recovered Plastics - Relative value of different grades	
4. Typical range of considerations taken into account during the design of packaging	

Case studies	
1. Polythene bottle	
2. Nestle Waters France	

# Introduction



Picture courtesy of BSDA and Coca-Cola Enterprises

Climate change and sustainable development are two of the biggest issues facing society today. It is therefore increasingly important for companies to reduce the environmental impacts of products and services through their whole life cycle. Companies failing to address environmental performance in product design and development will find it increasingly difficult to compete in the global market.

Packaging should be designed to satisfy technical, consumer and customer needs in a way that minimises environmental impact. This means, that amongst other things, packaging should be designed to use the minimum amount of resources for purpose and once it has completed its job, the scope for recovery maximised.

These guidelines focus on the design of plastic packaging to facilitate recycling and represent a small but important aid for the journey to sustainable production and consumption.

## Background to document

The objective of this project has been to produce a definitive general guidance document that has wide international agreement. It will provide plastics packaging designers, in particular, with a better understanding of the environmental implications of their design decisions, thus promoting good environmental practices but without unnecessarily restricting choice. Designers can be reassured that through following these recommendations, their plastics packaging should not cause recycling issues in any European country

and be acceptable internationally.

Whilst design guidelines have already been produced by a number of industry associations, this work, for the first time, pulls together into one simple document commonly agreed best practice and provides the business case for following the guidelines. The document is not intended to compete with these existing documents but rather pull the information together and address the issues in a way that will encourage packaging designers and specifiers to follow agreed good practice. The process used to generate the document and the organisations consulted are summarised in Appendix 1. The current document is an update for the first version (V1), originally published in April 2006.

The advice contained in the document has been provided both to help users maintain the value of the post-used material resulting from the mechanical recycling of their packaging and to avoid significant interference with established recycling processes and material streams. Appendix 2 summarises the key aspects concerning the recycling of plastics.

## Document scope

This practical document seeks to answer in a pragmatic way many of the immediate questions for designers and specifier of plastic packaging. The guidelines provided here are broadly applicable and internationally consistent at the time of publication.

This document does not attempt to provide a full strategic overview of all issues in plastic packaging recycling. The authors acknowledge that guidance on designing for recyclability is one component only of a larger sustainability challenge. There are wider issues of relevance, both in considering the overall environmental impact of differentiated packaging systems, and in developing efficient operational solutions to recycling and recovery of used plastic packaging. It is noted that continuing work will be required by many parties including designers, manufacturers, waste and resource management professionals and governments to address these developing issues.

It is important to note that since the packaging market is characterised by innovation, there are specific circumstances where the relationship of packaging production and recycling continues to develop.



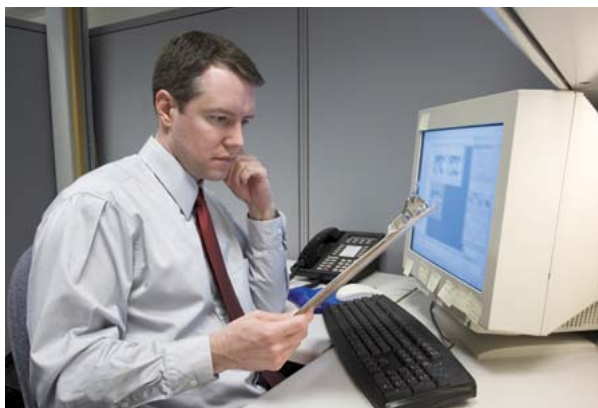
There will also continue to be developments in the use of labels, glues and other packaging components. In addition good practices will develop and, changes in regulations will continue. For example, at the time of publication the European commission has only recently published a Regulation (EC No 282/2008) on harmonising the approach to the use of recycled plastics in food contact applications in Europe. This new regulation requires traceability of supply chains for food grade recycling and potential future requirements are likely to increase demands in this area even more. As a consequence this may lead to additional recommendations for designers as well as for those involved in the logistics of recycling to ensure that compliance with the current and future regulatory standards is achieved.

## Aims

The aim of this document is to encourage designers to consider recycling possibilities, provide guidelines for those wishing to make their packaging (more) recyclable and provide everyone with information to prevent their packaging inadvertently interfering with existing plastic recycling streams.

Pursuit of these aims must be proportionate: The guiding principle for any packaging design should be "fitness for purpose". Thus the goal of improving the recyclability of the packaging cannot compromise product safety, functionality or general consumer acceptance and should positively contribute to an overall reduction in the environmental impact of the total product offering. It is recognised also that recycling packaging is not always the most environmentally or economically sound option and therefore the intention is not necessarily to try and make every piece of plastic packaging recyclable. Energy recovery or composting is sometimes a more responsible option, depending on the nature of packaging and the local solid waste management infrastructure. These recovery routes are complementary and their relative use needs to be optimised to meet local conditions, thereby providing an integrated and sustainable approach to packaging waste management<sup>2</sup>.

Following these guidelines will also help European companies demonstrate compliance with the European recycling standard linked to the Essential Requirements legislation and more generally, will aid demonstration of 'due diligence.'



## Is this document relevant to me?

This document is of relevance to anyone specifying, designing or using plastic packaging. The focus is on plastic packaging that ends up in the domestic waste stream but it is also of relevance to commercial & industrial waste streams.

The document gives practical advice and information on environmental considerations to the whole supply chain i.e. designers, packaging technologists, buyers, marketing and retailers but is primarily focused on those responsible for specifying the packaging being used. Any specifier following the guidelines can be reassured that their packaging should not cause recycling issues.

This document consolidates and develops information from various sources in Europe and North America to provide a comprehensive guide on plastics packaging design best practice. It is therefore particularly relevant to companies selling into markets across Europe and the USA but has more general international relevance.

<sup>2</sup> Nonetheless mechanical recycling often represents the optimum recovery route for plastics packaging and in a number of countries no real alternative to recycling currently exists.

# Questions and answers

## Why is recycling important?

Society will expect that a large amount of the plastic packaging that you use is designed for recycling and will be recycled (see Appendix 3). In addition, legislation in Europe requires that Member States mechanically recycle at least 22.5% of the plastics packaging put onto the market and that you ensure that any plastic packaging you use does not negatively interfere with current recycling streams (see Appendix 4).

## Why should I follow the guidelines?

Businesses have to deal with continuously more demanding societal expectations in the way that they operate. Such pressures arise both through environmental non-governmental organisations (NGOs) and increasingly demanding legislation. With the growing awareness of the importance of sustainable development, the environmental impact associated with companies is under ever more scrutiny.

Packaging has a very negative perception with consumers and environmentalists. It is perceived to be a waste of resources and a significant contributor to the growing levels of waste<sup>3</sup>. In addition it is often also linked to litter issues. Politicians are very aware of this with the result that pressure has been, and continues to be applied on packaging through the introduction of legislation in Europe, the USA, Japan and other countries around the world. In addition, recycling is seen by many as the most important recovery route and therefore the one that should take precedence (Appendix 3).

Following these guidelines will at a minimum, provide an important contribution to help you ensure that your packaging is compliant with relevant legislation / agreements, that recycling costs are minimised and that societal expectations and your company practices are matched in the area of plastics packaging recycling.

The document however is designed to go beyond being a simple aid to legal compliance: It provides up-to-date guidelines that can be used to support a process of continuous environmental improvement, a key element of both Sustainable Development and Corporate Social Responsibility.

## Are there benefits to me, if I follow the guidelines?

The guidelines allow you to maximise the opportunity for your packs to be mechanically recycled whilst avoiding significant interference with established recycling processes and material streams (requirement of European recycling standard linked to legislation) without unnecessarily restricting choice.

Adopting these guidelines at the start of the design phase will ensure unnecessary difficulties are avoided and hence unwanted project delays and associated on-costs prevented.

A number of countries across Europe seek to reward packaging that conforms to specific design rules and / or penalise those that don't. Compliance with these guidelines will help ensure that you obtain any benefits and avoid potential penalties in this area.

Following these guidelines will help minimise the costs to your company in satisfying its recycling obligations under European legislation and national / state agreements by maximising recycling efficiencies and thus minimising reprocessing costs.

A fuller explanation of the benefits to you and your Business of following the recommendations in these guidelines is given in Appendix 5.



<sup>3</sup> While packaging is a significant fraction of household waste (20-25%), domestic waste makes up <20% of waste sent to final disposal. Hence packaging waste represents <5% of waste in a landfill.

## What are you asking me to do?

For existing plastics packaging, you are asked to review your current portfolio against these recycling guidelines, highlight any aspects where the design could be improved and then implement changes as soon as possible, as the opportunity arises.

For new packaging, you are asked to integrate these guidelines into the design process at the start, to minimise cost and maximise the opportunity for compliance.

More generally, these guidelines should be integrated into any Environmental Management Systems (e.g. ISO 14001) and new product innovation protocols that you have and become part of your automatic environmental assessment process for new products.

## Will it cost me money?

Adoption of good eco-design practice should not result in an on-cost provided that these aspects are considered along with the many other business factors at the start of the design process. Conversely, if environmental considerations are only factored in at the end of the design process, then any changes necessary are likely to be costly in terms of both money and project delays.

Following the guidelines should help you reduce costs by:

- helping to ensure that your company is compliant with relevant legislation (e.g. the recycling requirements of the essential requirements legislation of the European Packaging and Packaging Waste Directive) / voluntary agreements
- minimising company recycling costs
- matching societal expectations and company practices in the area of plastics packaging recycling.

Conversely, the potential consequences to a business of getting these aspects wrong in terms of legal, market share and corporate image issues can be significant.

## Where can I get more information

The current guidelines provide a good point of entry. This document consolidates and develops information from various sources in Europe and North America to provide a simple but comprehensive guide on plastics packaging design best practice. Any specifier following the guidelines can be reassured that their packaging should not cause recycling issues. This document will be periodically updated and readers can access the most up-to-date version at the following web address [www.recoup.org/design/rbdv2](http://www.recoup.org/design/rbdv2)

The document also provides reference to key industry organisations and web sites dealing with the recyclability and recycling of plastics packaging in both Europe and the USA. You are encouraged to visit the web sites and if necessary, contact the relevant organisation(s) to discuss any specific issues not covered within the current guidelines or obtain further information on a specific area<sup>4</sup>. These organisations can also help put you in touch with your local organisation should this be desired.

## Conclusion

Following these design for recyclability guidelines will be an important contributor towards helping to ensure that companies are compliant with relevant legislation / agreements, company recycling costs are minimised and that societal expectations and company practices in the area of plastics packaging recycling are matched. In addition, the production of consistently high quality, post-use plastic material will overcome the quality and consistency supply issues experienced in the past.

This, together with its lower cost, will make it commercially a more attractive raw material and thus help to further stimulate sustainable secondary markets. Thus the use of post consumer plastic in packaging whenever possible is encouraged.



<sup>4</sup> Please note that some organisations may provide information only to their members or may charge for providing the desired information.

## Introduction

The aim of these guidelines is to encourage packaging designers to consider recycling possibilities, provide guidelines for those wishing to make their packaging (more) recyclable and provide information to prevent packaging designs inadvertently interfering with existing plastic recycling streams.

The goal of improving the recyclability of packaging should not compromise product safety, functionality or general consumer acceptance and should positively contribute to an overall reduction in the environmental impact of the total product offering. Equally, the authors acknowledge that guidance on designing for recyclability is one component only of a larger and complex sustainability challenge: All resources need to be used efficiently and in the context of packaging this requires that initially the minimum amount of materials are used for purpose and that used materials are ultimately efficiently recovered. It is recognised that recycling packaging is not necessarily the most environmentally or economically sound option. Sometimes energy recovery or composting may be a more responsible option, depending on the nature of packaging and the local solid waste management infrastructure.

The guidelines have been compiled to help maximise the opportunity for plastic packaging to be mechanically recycled without unnecessarily restricting material choice and to help maximise the value of the post-used material resulting from the mechanical recycling of the packaging, while recognising that it is not necessarily desirable to make every piece of plastic packaging recyclable. The document is designed to go beyond being a simple aid to legal compliance: It provides up-to-date guidelines that can be used to support a process of continuous environmental improvement, a key element of both Sustainable Development and Corporate Social Responsibility.

Careful selection of materials at the design stage will help overcome potential legislative issues, reduce cost and help conserve resources by avoiding obstacles to recovery, improving yields, producing less waste and ensuring a higher value of the recovered material.

The information contained within the guidelines implies no criticism of any material and merely seeks to point out that certain combinations should be avoided to maximise the recyclability of the plastic packaging in question. Plastic materials that cannot be processed with the main material at best reduce reprocessing yields and can, unless care is taken in the design, significantly reduce process efficiency and introduce unacceptable costs. Matrices summarising material compatibilities are provided within each material specific guideline (see pages 14-23).

Following the recommendations provided in these guidelines should avoid the necessity to evaluate component compatibility. However, if use of non-recommended material combinations is desired, then the user may arrange for more definitive compatibility evaluation tests<sup>5</sup> to be carried out. The key organisations listed in Appendix 7 have developed testing protocols that can be used to accurately assess the compatibility of packaging designs with a specific material recycling stream<sup>6</sup>. In addition, specific applications (e.g. food contact) may stipulate more demanding requirements than provided in these general guidelines (e.g. case study given on page 14).

## General principles for container / Components

In an ideal world, use of mono-materials or mixed materials of the same type are the preferred choice from a recycler's point of view. In this context, type means materials that for all intents and purposes act as if they were a homogeneous material i.e. they are fully compatible, do not downgrade the properties of the recycled plastic and can be sorted and subsequently processed as if it were a single material.

It is recognised that to provide both the technical properties required and to satisfy user needs, sometimes a combination of different types of material is required. Under these circumstances, materials of different densities should be used to facilitate the separation of incompatible materials during mechanical shredding or crushing, or during the subsequent water-based washing process. Combinations of different types of plastic with the same density ranges should be avoided. Fillers that change the density of the plastic should be avoided and/or their use minimised in general as they lower the quality of the recycled material.

<sup>5</sup> COTREP in France recommends using the results of evaluation tests before coming to any definitive conclusions on the recyclability of the packaging design. APR in the USA through their Champions for Change program invites packaging designers / users to participate in co-operative testing to understand the impacts of packaging innovations on the recycling of bottles. APR lists at its web site various test procedures.

<sup>6</sup> APR have also developed Critical Guidance Documents for HDPE and PET that provide a short list of laboratory tests and evaluation criteria to help designers understand the impacts of their innovations on plastic bottle recycling.

Unpigmented polymer has the highest recycling value and the widest variety of end uses. Therefore use of unpigmented containers / film is preferred to pigmented.

For food contact applications, the additional specific requirements of traceability, guarantee of the use of qualified processes and producer responsibility for recyclates would ensure that specifiers use only food-approved additives to maintain the potential for the recycle to be subsequently used in food applications.

## Residues

To help ensure packs are emptied to their maximum, packaging designers should carefully consider what good design features can be incorporated to aid the emptying of packs. For example:

- Design the pack with a wide neck
- Consider using a pack that can be stood inverted to ease emptying.
- Investigate use of non-stick additives to reduce the cling of contents to the container to ease emptying. Such additives should not however affect the ultimate recyclability of the pack.

No firm target figures can be provided as to what constitutes acceptable residue levels as these will be very dependent upon pack size and product viscosity. As a rough guide however, for non viscous products (i.e. where thickness is similar to water) aim for 50ml-99ml bottle residues <10%, 100ml-499ml bottles < 5% and 500ml+ bottles <2% bottle residues of declared contents when considered empty. For viscous contents it is not practical to set target residue guidelines as the amount of residue depends in part on the properties of the contents.

## Composite materials / Barrier layers

Where a composite material is necessary to provide the requisite properties (e.g. provide a barrier function) and cannot be designed in such a way that the different types of materials can be separated mechanically or are compatible with the recycling stream, consideration should be given to the use of thin layers (e.g. vapour deposition).

It should be recognised that lightweight plastic laminates (especially those of thickness <100

microns) which are highly engineered and weight effective packaging materials, in general are not cost-effective to recycle. Energy recovery is the optimum recovery route (in Europe at least) for such materials.

## Colour of plastic

Colour interferes with the mechanical recycling process in two main ways: Firstly, strongly coloured plastic material has a much lower economic value than non-pigmented plastic. Secondly, heavily coloured (and hence strongly light absorbing) plastic may interfere with automated sorting machinery that uses NIR spectroscopy to identify the nature of the plastic. Such equipment relies on the reflection of NIR radiation and thus cannot identify strongly light absorbing objects.

The amount of colour to be used should be minimised as much as possible within the constraints set by technical considerations, branding and consumer acceptance. Where use of colour is necessary, designers are encouraged to consider alternative approaches (e.g. sleeves) that will further facilitate recyclability. Sometimes using colour may offer overall resource benefits, for example in the reduced use of energy during bottle blowing. Some soft drinks manufacturers use fast reheat plastic resins that necessarily contain carbon black. Sometimes these resins are coloured to mask containers having an otherwise grey appearance.

Avoid direct printing onto natural (not coloured or opacified) plastics.

Readily separable attachments allow reprocessors to remove associated contaminants such as pigments, inks and residual adhesives raising the quality of the recycle. This is particularly significant when the primary packaging polymer is colourless or 'natural'. When the primary packaging polymer is pigmented, e.g. coloured HDPE, the reprocessor specification is less sensitive to low levels of ink contamination and in this case the polymer type of the label, cap and other attachments should be matched to that of the container.

In the future, these restrictions may be able to be relaxed with the commercialisation of feedstock recycling plants.



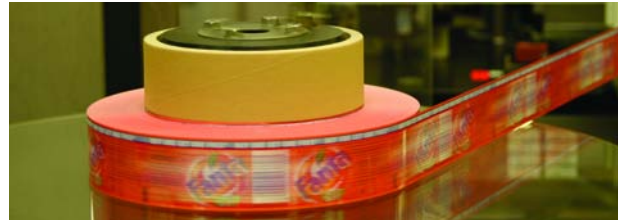
## Closures / Closure liners / Cap sleeves / Seals

Closures, liners and cap seals should not interfere with the recyclability of the material to be recycled and ideally be recyclable themselves, preferably in conjunction with the plastic of the main container. Unfortunately, this does not mean PET closures on PET bottles. Ideally, PP closures are used on PET bottles.

Closure systems that contain no liners and leave no residual rings or attachments when removed are optimum. Designers should assume seals may be pushed back into empty containers and choose materials accordingly.

Avoid use of metal caps. They are more difficult and more costly to remove in conventional reclamation systems compared to preferred plastic closure systems. Metal residues cause unacceptably high plastics' rejection rates with the metal detectors installed in sortation lines and residues can catalyse polymer oxidation and block injection nozzles. Automatic sortation equipment such as eddy current units or electrostatic separation equipment can remove aluminium closures from recovered polymer. However, not all reprocessors have such equipment and small amounts of aluminium may remain to cause problems. In addition, most reprocessors use a caustic wash and any aluminium residues will be converted to aluminium hydroxide which will then become a contaminant in the recycled material that could prevent its suitability as a food grade material (e.g. in the case of PET). Use of threaded / snap-on metal closures should be avoided, as these can be difficult and relatively expensive to remove. Prise-off (crown) caps are acceptable provided they are completely detached from the bottle on opening and cannot be pushed back on / into the container.

In certain circumstances, seal residues and minor components of a different type of plastic if present in very minor amounts, may not significantly interfere with the recycling process or the quality of the recycled material.



Picture courtesy of BSDA and Coca-Cola Enterprises

However this should not be assumed and would need to be checked with the relevant organisation listed in Appendix 7.

In applications where tamper-resistance is required, integration into the design feature is preferable. Provided functionality can be maintained, sleeves and safety seals should be designed to completely detach from the container or be easily removed in conventional separation systems. Otherwise they will act as contaminants.

## Labels / Safety seals / Adhesives

The type of labels and adhesives used has important implications for ease of container recycling.

Amount of adhesive used and surface coverage should be minimised to maximise yield and ease reprocessing. Water soluble (or dispersible) at 60 to 80°C (140 to 180 °F) and hot melt alkali soluble adhesives are the adhesives of choice as they are the most readily removed during reprocessing. Label adhesives that can't be removed can coat the plastic regrind and embed unwanted contaminants.

The European Plastics Recyclers (EuPR) have produced a list of hotmelts acceptable for mechanical recyclers that can be found on their web site.<sup>7</sup> This list is not exhaustive and other adhesives may also be suitable. APR in the USA have also developed testing protocols for adhesive manufacturers to use to evaluate the impact of any adhesive product on conventional PET and HDPE bottle reclamation systems. The European PET Bottle Platform also has developed similar protocols to test acceptability of adhesives in conventional European bottle recycling systems.

For bottles, sleeves and wraparound or collar labels that are only glued to the container at a few points are optimum.

Foil safety seals that leave remnants of the foil and / or adhesive should be avoided.

<sup>7</sup> <http://www.plasticsrecyclers.eu/docs/docs/useful006.pdf>

Labels should not delaminate in the washing process.

Use of paper labels on bottles is not ideal as some fibres can be carried over into the recycled plastic causing problems such as surface defects and pinholes during the blow moulding of the recycle. They are acceptable, however, provided they are attached using water soluble adhesives and are not coated in such a way that prevents separation and removal from occurring during reprocessing. For this reason use of decorative / protective finishes (e.g. foil, lacquers, coatings etc.) should be minimised. Paper labels must not however pulp in the wash tank.

Use of paper labels on plastic film presents a significant problem to conventional recycling and therefore needs to be avoided. These labels are costly to remove and if left, significantly devalue the quality of the collected material.

Metallised / foil labels increase contamination and separation costs and should be avoided whenever possible. If used at very low levels, such labels are unlikely to be detectable by metal detectors but this cannot be guaranteed. Deposition techniques that provide a very thin layer of metal (only atoms deep) are acceptable however and are the method of choice to provide a metallised effect on labels.

Use of a material of a different type for the sleeve offers the opportunity to colour and decorate the surface of the container to a very high percentage whilst avoiding colour contamination of the main material. This helps to maximise the value of the recycled material (see section on colour of plastic).

Where in-mould labelling is desirable (e.g. to protect containers frequently coming into contact with oils or water) the same plastic as the container or a plastic of the same type should be used wherever possible.

Reference should be made to the specific material sheets to obtain more detailed information about acceptable options for label materials.

The choice of label should not have the potential to lead to an error in the identification of the material used for the container itself. This is why various published guidelines often stipulate that the sleeve labels should cover no more than 40% of the bottle surface. Thus, full bottle sleeves, if desired, need to be so designed that automatic sortation equipment can properly identify the polymer resin used to make the bottle.

## Pigments / Inks

Inks and pigments selected to colour and print the container and label already have to comply with existing restrictions on the use of heavy metal components and, although beyond the scope of these guidelines, also with relevant health and safety regulations. In any case, hazardous substances should be avoided in the interests of good manufacturing practice and heavy metal inks not used for printing as they may contaminate the recovered plastic. For these reasons, it is recommended that the regularly updated exclusion list for printing inks and related products, provided by the European Printing Ink Association (EuPIA) is followed<sup>8,9</sup>.

Inks that would dye the wash solution should be avoided as this may discolour the recovered plastic diminishing or eliminating its value. APR, NAPCOR and The European PET Bottle Platform have testing protocols to assist label manufacturers to assess whether a label ink will bleed in a conventional PET recycling process.

Heavily pigmented containers should be avoided. They can result in a significant increase in the density of the polymer thereby causing separation problems and can also cause problems for automated sorting equipment using NIR sensors.

## Other components

The use of other components of a different material (e.g. handles, pour spouts) is discouraged as they may reduce base resin yield and increase separation costs. When required, compatible materials (preferably unpigmented) should be used.

There is a progressive request, primarily from retailers, for RFIDs (Radio Frequency Identification Devices) to be applied to packaging. While these tags offer potential logistics and other benefits, they are in general undesirable from a recyclability point of view at present as the adhesives and metals reduce efficiencies and / or contaminate the recycling stream. Use of RFIDs on bottles, labels or closures is discouraged and therefore should be avoided unless they can be shown to be compatible with the relevant conventional plastics recycling stream and demonstrated not to create any disposal issues based on their material content.

<sup>8</sup> <http://www.eupia.org/homepage.htm>

<sup>9</sup> EuPIA is the printing ink group within the European Council of Paint, Printing Ink and Artists' Colour Industry (CEPE)

# General guidelines



## Material identification

To facilitate the visual identification of plastic types during manual separation, major plastic components (container, caps, and lids) should carry a material identifier. Material identification is also of use when recycling industrial waste either internally or externally or where clean waste streams, components or packaging are being recycled from industrial / commercial sources where washing / separation is unnecessary.

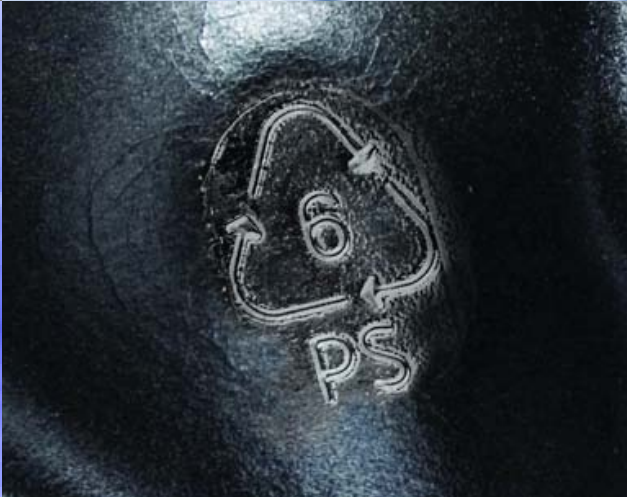
In Europe, material identification is voluntary, but if it is to be used then Commission Decision 97/129/EC should be followed although the widely adopted and substantially similar SPI system, developed in the US for plastics, seems also to be acceptable (Appendix 8).

The symbol should be shown clearly and ideally moulded into the container / component or in the case of films, lightly and repeatedly printed across the material.

On containers, the marking should be clearly distinct from any other letter or cavity reference number to avoid confusion. For consistency, material identifiers should generally be embossed on the base of a container. Exceptionally, the identifier can be located on an alternative position close to the base (e.g. to avoid the risk of cracking due to bottle design) or the identifier (for the predominant material) printed on the label. (Printing the material identifier on a label whilst convenient, potentially leads to confusion as it could refer to the label material, the container plastic or the full container, including closure).

Additional information given on the label should not confuse manual sorters.

With the increasing use of automated sorting for household waste, the recycler's need for material identification is becoming much less important, although consumers and environmentalists may still wish for it to be present.



# General guidelines

Material identification

## Material specific guidelines

These are general guidelines that apply to all plastic materials used for packaging. Specific guidelines have also been produced for plastic packaging where the main material is based on PE, PP, PET, PS or PVC. These material specific guidelines complement the general guidelines and should be used in conjunction with them where appropriate. In the unlikely event that the general and specific guidelines appear contradictory, the material specific guidelines should take precedence.

The compatibility matrices contained in the material specific guidelines are divided into three columns, namely:

- YES,
- CONDITIONAL
- NO

The meaning of these three columns is as follows:

**Table 1: Explanation of terms / colour coding in material specific guidelines tables**

YES	CONDITIONAL	NO
Generally the material is compatible with or separable from the main material and is acceptable in industrialised recycling processes in large volumes.	Use of material in general is undesirable and could cause severe recycling issues if used in large volumes. Under certain specific conditions the material may be recyclable, but this would need to be confirmed with the appropriate recycling organisations and / or recyclers.	Material is generally not compatible with or separable from the main material in current industrialised recycling processes and will therefore cause severe recycling issues / cause rejection of recyclate if present even at low volumes.

It should be noted that under certain circumstances suppliers may require, for a specific application, recycled material that conforms to the most demanding requirements outlined in the material compatibility matrices supplied in this document, as evidenced by the following **case study**:

### Case Study 1 - Polyethylene

For the manufacture of food grade polythene bottles from recycled HDPE, one UK manufacturer highlights the importance from a recyclability perspective of the HDPE material stream including only containers made from HDPE, linerless HDPE caps, labels made from only HDPE or paper and that any inserts or other minor components are also manufactured from only HDPE.



## Markets for recycled plastics

Recycling benefits and economics are maximised when the quality of the recyclate is appropriate and there are strong and diverse market outlets for the secondary material recovered. Today, there are opportunities to manufacture a range of plastic packaging products, including food grade applications such as containers and trays, with a proportion of recycled plastic. In this latter case, traceability is a critical parameter. Designers should consider the possibility of including recycled plastics in their packaging for both environmental and commercial reasons.

## Integration of environmental and legal aspects into the packaging design process

The design of packaging is a complex process and is often a key element of product change / new product introduction. If environmental and regulatory assessments are included with the wide range of inputs that have to be taken into

account at the start of a project they can become part of the process of maximising the product opportunity. Where environmental considerations are an afterthought issues are invariably more difficult to resolve and can lead to significant on-costs and serious time delays.

It is recommended that companies adopt a new product innovation process that automatically includes an environmental assessment. Ideally, this environmental assessment becomes part of a recognised environmental management system (e.g. ISO 14001). The European CEN standards (see Appendix 4) provide an excellent management approach for carrying out this environmental assessment<sup>10</sup>. Following these standards should ensure that companies automatically cover the key environmental aspects that need to be addressed for packaging. Use of the present document by packaging designers / specifiers should help ensure that the key criteria covered in these standards concerning plastic packaging has been satisfied.

Further explanation together with a case study is given in Appendix 9.



## Disclaimer

*The information contained in this document is for general guidance only. Any details given are intended as a general recommendation based on the best of our knowledge at the time of publication. It does not necessarily guarantee compliance with the different recycling schemes. This is by no means a comprehensive list. Users are therefore advised to make their own enquiries to check for specific and up-to-date information.*



Above.  
Flaked Recyclate.



Above.  
bottle to bottle and watering cans are examples of the possible use of recycled plastics

<sup>10</sup> EUROPEN has published a guidelines document to the use of these standards by companies

# 1. General

The recommendations given in this section cover PET bottles. As explained earlier, these guidelines are driven by the requirements of the mechanical recycling process. In the future, some of the current restrictions (especially for barriers / opacity / colour) may be relaxed as feedstock recycling plants come into commercial operation. These benefits are likely to be realised first with PET packaging, as these plants are likely to focus first on PET as the source material.

For efficient separation and removal in conventional density separation processes, parts of the packaging system that are not compatible with PET should have a density < 1 g / cm<sup>3</sup>.

## 1.1. Material / Material Combinations

Contaminants which generate acidic compounds during extrusion cause problems when recycling PET, as these catalyse ester depolymerisation reactions, decreasing intrinsic viscosity. A range of contaminants including PVC, rosin acids from label adhesives and EVA cap liners can act as sources of acids. PVC contamination is a potentially major problem as the similar appearance and overlapping range of densities make the two polymers difficult to separate. PET melts between 250°C and 260°C, and at this temperature PVC begins to decompose producing HCl. The presence of very low levels of PVC (ca50-200ppm) in recycled PET results in measurable deterioration in chemical and physical properties and can render large amounts of PET useless for most recycling applications. For this reason, the use of PVC components of any kind with PET containers should be scrupulously avoided. These components generally include, but are not limited to closures, closure liners, labels, sleeves and safety seals.

Other types of PET<sup>11</sup> that share the same material identifier may cause problems in separation and conventional recycling.

Use of PLA (a biodegradable material) with PET should be avoided as the polymers are incompatible and not readily separable (both have a density > 1g/cm<sup>3</sup>). The presence of very low levels of PLA in PET causes haze and a deterioration of physical properties with the recycled PET. In addition, PLA causes processability problems in the drier as it melts at the drier temperature.

Blends of PET with other resins are undesirable unless they are compatible with PET recycling.

Inclusion of nucleating agents, hazing agents, fluoescers, scavengers and other additives for visual and technical effects should be examined on a case by case basis for their impact on the overall plastic recycling stream. Such additives which cause the PET to discolour and/or haze should be avoided unless means are readily and economically available to minimise their effect.

## 1.2. Barriers / Coatings

New PET bottles incorporating additives or barrier materials to further improved barrier performance are continuously being developed and will at some time challenge existing recovery schemes. Non-PET multi-layers or coatings are not always fully compatible with current recovering technologies and may reduce recoverability of PET bottles. Indeed, constituents can be difficult to separate. (It is accepted that newer containers and containers for oxygen sensitive contents may be multi-layer and will therefore require additional attention during recovery operations). The European PET Bottle Platform has published guidelines to help the PET production, filling and recovery chain evaluate the impact of such bottles<sup>12</sup>.

EVOH barriers in particular have a history of causing significant issues<sup>13</sup> during recycling if residual levels are >= 500ppm. Petcore have endorsed one specific 5-layer PET bottle with two thin layers of EVOH as barrier<sup>14</sup>. This demonstrates that under specific circumstances

(technology / levels etc.) EVOH can be acceptable. However the specific requirements for acceptability are not generally achievable by European recyclers and recovery rates of the PET would be low<sup>15</sup>, thus the recently formed European PET Bottle Platform (of which Petcore is a member) remain against the current use of EVOH as a barrier with PET bottles. This view is also reflected in the USA. Hence EVOH as a potential barrier material with PET is not recommended at this time. As indicated previously, if use of this non-recommended material combination is still desired, the user may arrange for more definitive compatibility evaluation tests to be carried out. Product manufacturers and their suppliers would need to ensure that before launching onto the market that levels employed are minimised and that data to show that the proposed packaging provides both a recyclate that satisfies all technical requirements (especially discolouration and haze) and that recyclers in general can achieve the separation efficiencies required<sup>16</sup> is available.

Alternatively, where performance enhancing barrier layers are used which could interfere with current recycling, for example in PET beer bottles, it is important to ensure that the container is easily distinguished and sorted from conventional PET bottles. For example, in the past, PEN was becoming progressively more used to provide additional barrier properties. When PEN in varying amounts is reprocessed with PET the composition and physical properties of the recovered material varies, potentially restricting the range of applications for which it may be used and hence the value of the recyclate (e.g. PEN tends to brown on re-heating and fluoescres and this has implications for garments made from recycled PET fibres). Its use in packaging is restricted currently to the reuse market. If recycling is desirable when it eventually reaches the end of its useful life, then a separate recycling stream from PET will be necessary to avoid the issues discussed.

Clear plasma coatings in general cause no recycling issues, although use of high levels of carbon should be avoided. Other external coatings (e.g. O<sub>2</sub> or CO<sub>2</sub> barriers) can cause issues. To be acceptable the barrier needs to flake off the PET and be efficiently removed during reprocessing. European PET Bottle Platform protocols have been developed to test suitability.

## 1.3. Colour

Non-coloured, unpigmented PET not only has the highest value and the highest recovery rates but also the widest variety of end markets. At present, tinted (other than light green and blue tints) or opaque<sup>17</sup> PET bottles are not desirable to many PET recyclers because the quality of their end products are colour sensitive. As a result, coloured PET is rejected by many recyclers and can interfere with the recycling process and therefore its use should be avoided as much as possible.

The use of opacifiers should be avoided as they significantly reduce the value of the PET recyclate. The presence of TiO<sub>2</sub> in particular causes breakage during fibre production and thus use of this opacifier in particular should be avoided.



<sup>11</sup> PETG, a modified PET, melts at ca 230°C but starts to go tacky at 80°C. PET flakes go through a drier at 170-180°C and thus the presence of PETG will cause these flakes to stick together causing significant issues to the reprocessor. Also if PETG in varying amounts is reprocessed with PET the composition and physical properties of the recovered material (e.g. melting point) also vary, potentially restricting the range of applications for which it may be used and hence the value of the recyclate.

Some PET polymers fluoescres and these should also be avoided as they restrict end-use markets.

<sup>12</sup> e-mail: plarebel@essenscia.be

<sup>13</sup> Causing haze and colour issues at low levels and deterioration of mechanical properties at higher residual levels

<sup>14</sup> Graham Packaging bottle using their 5-layer PET bottle (SurShot co-injection technology) where the EVOH barrier (SurBond-ETM) is present in two thin layers. This fulfils the requirements of the Petcore bottle to bottle and bottle to fibre protocol provided additionally that the barrier is present at a level of up to a total weight of 2% and that no compatibiliser that could enhance bonding or decrease separation is used.

<sup>15</sup> All the five layers are of similar thickness and thus as much PET as barrier is removed during reprocessing.

<sup>16</sup> The removal during the elutriation process is high and the volumes used are unlikely to have a significant effect on the PET recycling stream.

<sup>17</sup> In particular TiO<sub>2</sub> is very detrimental to PET bottle-to-bottle recycling and engineered polymer uses.



# PET

Material specific guidelines

## 1.4. Closures / Closure Liners

EVA liners are only acceptable in combination with plastics. When combined with aluminium they cause contamination and thus should not be used. Conventional silicone seals (density  $\geq 1 \text{ g/cm}^3$ ) are neither compatible with PET or easily separable and therefore should not be used in combination with PET. Seal manufacturers have recognised this problem and are now designing silicone seals with a density  $< 1 \text{ g/cm}^3$ . These seals should be separable from the PET and avoid potential issue. Given the newness of this innovation, potential users are recommended to check that the supplier can provide proof of the compatibility of the seal with conventional PET recycling. (It is also worth noting that whilst this development was designed to overcome potential issues within the PET recycling stream, these lower density silicone seals have the potential to end up in the polyolefin stream and adversely effect the quality of this stream).

Closures made from PS or thermoset plastics are undesirable and should be avoided. In general the use of aluminium closures should be avoided, as they are more difficult to separate from bottles compared to the preferred closure systems (PP and HDPE) and add both capital and operating costs to conventional reclamation systems.

Foil safety seals that leave foil or remnants or attaching adhesive on the PET bottle should be avoided.

## 1.5. Labelling

Polyethylene and polypropylene are the preferred label materials. Foil, lacquered and coated labels become contaminants and are undesirable. While PS labels are tolerated by many PET recyclers, to ensure that they can be separated easily in the floatation or wind sifting processes, they should only be used where the PS material is of low-density form (i.e.  $< 1 \text{ g/cm}^3$ ) such as a foam.

Presently all direct printing and decoration contaminates recovered PET in conventional reclamation systems and discolours the base material. Colour and printing therefore (other than date coding) should be confined to labels.

## 1.6. Other components

It is preferred that base caps, handles, transportation aids and other attachments are avoided but if used, they should not be welded to the container. If attachments are glued on, they should separate in hot aqueous detergent or caustic solution ( $60$  to  $80^\circ\text{C}$ )



# PET

Material specific guidelines

Table 2: PET Bottles

		YES	CONDITIONAL <sup>1</sup>	NO
BODY 2	Material	PET		PLA / PVC / PET-G
	Colour	Clear / Light-blue / Green	Other transparent colours	Opaque <sup>8</sup>
	Barrier / Coatings	Clear plasma coating	External coating / PA - 3 layers (e.g. MXD6 3 layers),	EVOH / PA monolayer blends
	Additives		O <sub>2</sub> scavengers / UV stabilisers / AA blockers / Nanocomposites	
CLOSURE	Caps	PP <sup>4</sup> HDPE, LDPE - Europe only	HDPE, LDPE - USA only	Steel / Aluminium / PS / PVC / Thermosets
	Liner	HDPE / PE+EVA / PP		PVC / EVA with aluminium
	Seals	PE / PP / OPP / EPS / Foamed PET	Silicone <sup>6</sup> (density $< 1 \text{ g/cm}^3$ )	PVC / Aluminium / Silicone (density $\geq 1 \text{ g/cm}^3$ )
DECORATION	Direct Printing	Production or expiry date		Other direct printing <sup>9</sup>
	Labels	HDPE / MDPE / LDPE / PP / OPP / EPS (density $< 1 \text{ g/cm}^3$ ) / Paper <sup>5</sup>	PET Metallised labels <sup>7</sup>	PVC / PS (density $> 1 \text{ g/cm}^3$ )
	Sleeves (incl. tamper resistance)	PE / PP / OPP / EPS (density $< 1 \text{ g/cm}^3$ ) Foamed PET / Foamed PET-G	PET	PVC / Full body sleeves PS (density $> 1 \text{ g/cm}^3$ ) / PET-G
	Glue <sup>3</sup>	No adhesive on body Water-soluble adhesive or alkali soluble adhesives ( $< 80^\circ\text{C}$ )		Adhesive not removed in water or alkali at $80^\circ\text{C}$
	Ink	EuPIA good manufacturing practices		Inks that bleed and dye wash-solution
OTHER COMPONENT			HDPE / PP / Uncoloured PET	PVC / RFID / Non-plastic

(1) Some materials / bottle components are recyclable under certain conditions. Please check with recyclers or recycling organisations.

(2) All materials must meet the legal requirements for materials and articles intended to come into contact with food.

(3) Ref. EUPR positive glue list

(4) PP caps are very much preferred over PE caps in USA as there is a good market for this secondary PP material stream.

(5) Acceptable provided firstly they are attached using water soluble adhesives and are not coated in a manner that prevents separation and removal during reprocessing (see Labels & Adhesives section of General Guidelines for more details) and secondly they do not pulp in the wash tank. Paper labels that do not satisfy these criteria should be avoided.

(6) Provided density is  $< 1 \text{ g/cm}^3$  and it has been demonstrated that cap liner does not cause any issue in conventional PET recycling facilities.

(7) Provided metalisation is 'light' metal detectors should not be triggered and recyclate acceptable.

(8) Main issue is when recycling back into bottles. Less of an issue when recycle being reprocessed into fibre. In general fibre production is not affected with up to 500 ppm TiO<sub>2</sub> and mica present (average particle size less than 50microns). TiO<sub>2</sub> and mica-based opacifying master batches, however, significantly disrupt PET recycling into strapping and bottle applications. Opaque bottles containing these master batches are systematically removed by recyclers from the part of the coloured stream intended for strapping and bottle applications.

(9) Experience from Mexico indicates that direct printing (generally black) at present it is not acceptable: It is very difficult to fully remove ink pigment (generally black), resulting in pinholing during reprocessing and residual solvent can also leads to yellowing. This position could change in future, depending on the outcome of testing currently ongoing within COTREP.



## 1. General

For efficient separation and removal in conventional density separation processes, parts of the packaging system that are not compatible with HDPE should have a density  $> 1 \text{ g / cm}^3$ .

### 1.1 Colour

Applications using clear, colourless polyethylene have the highest recycling value, therefore use of unpigmented containers is preferred. Coloured containers, tubes and films are acceptable.

### 1.2. Barriers

Some applications require the use of additional barrier layers for specific applications. The use of non-PE layers should be minimised (to maximise PE yield and reduce potential contamination and separation costs), but when required they should be compatible with or easily separable from PE in conventional recycling systems.

Current HDPE recycling systems can tolerate the use of low levels of EVOH layers. Similarly MXD6 and other nylon-based barrier layers are tolerated, particularly if the layers are readily separated from the HDPE in conventional reclamation systems. In all such cases their content should be minimised to the greatest extent possible to maximise HDPE yield and reduce potential contamination and separation costs. PVDC barriers should be avoided.

### 1.3 Additives

The use of additives / fillers such as calcium carbonate, talc etc. in concentrations that alter the density such that they cause the HDPE plastic to sink in water or alter the properties of the regrind are undesirable and should be avoided. For this reason, the HDPE density should be kept  $\leq 0.995 \text{ g/cm}^3$ .

### 1.4 Other Components

Use of PVC components should be avoided as they can cause discolouration and malodour.

## 2. HDPE Bottles

### 2.1 Material / Material Combinations

Unpigmented, homopolymer HDPE bottles generally do not use a multi-layer construction at present. It is possible that future bottle designs, however, might require the use of layers for specific product applications and then the barrier advice given in section 1.2 above should be followed.

The principal polymer contaminant of recovered HDPE is PP from bottle caps and bottles. HDPE and PP are opaque and less dense than water and consequently difficult for reprocessors to separate. Even in the small number of reprocessing plants able to separate PE from PP, this is not common as it is costly to carry out.

PP has a higher melting point (160-170°C) than HDPE (ca130°C), and so does not disperse readily in the HDPE recycle mix. PP contamination can limit the recovered HDPE specification to lower value applications. In general, a level of PP contamination up to 5% can be tolerated in the total mix and levels of PP cross contamination in finished product are frequently at around 5%. Higher levels e.g. 10% in the total mix can be tolerated for certain lower specification applications. When designing packaging, it is recommended that PP levels are restricted to a maximum of 5% to avoid potential end use issues. This is in line with US recommendations. Higher levels may be possible but this would require the difficult task of investigating the likely effects on the total mix during recycling.

HDPE is very susceptible to contamination from the contents e.g. pesticides, motor oil etc.) which can result in colour and odour problems. Whilst recyclate derived from milk bottles can result in malodour issues, this should be avoidable using a hot washing stage during reprocessing. HDPE containers used for mineral oil based products (e.g. motor oil) are not generally mechanically recyclable as they can cause residual malodour issues but more importantly, the oil migrates into the plastic and is not removed during normal reprocessing operations.

### 2.2. Colour

In general homopolymer bottles are unpigmented whilst copolymer HDPE bottles (detergent bottles) are pigmented. Indeed, some plastic recyclers use pigmentation as the basis for distinguishing and separating copolymer from homopolymer containers. For this reason a communication program to alert recyclers to the potential confusion should accompany any use of unpigmented copolymer bottles.

In multi-layer HDPE bottle designs, the use of inner layers of the same colour as the outer layer is preferred to maximise recyclability but inner and outer layers of different colour can be tolerated.

### 2.3. Closures

The use of closures that are the same colour as the bottle is desirable (although not essential).

Foil safety seals that leave foil or remnants or attaching adhesive on the HDPE bottle should be avoided.

### 2.4 Labelling

In applications using unpigmented, homopolymer HDPE, all direct printing other than date coding, used either for product labelling or decoration, presently contaminates the recycled unpigmented HDPE in conventional reclamation systems.

Use of PVC labels should be avoided as during the density separation the foil is so thin that it is carried over with the PE and does not sink as would be expected from its intrinsic density<sup>18</sup>.

### 2.5. Other attachments

The use of any other attachments is discouraged, as they reduce base resin yield and increase separation costs. If attachments are added to a bottle, they should be made from either materials that are easily separable from HDPE in conventional separation systems or are compatible e.g. PP, LDPE or preferably, unpigmented, homopolymer HDPE. Use of PP or LDPE attachments, if necessary, should be limited to less than 5 percent of the total bottle weight wherever possible as higher percentages can contaminate the HDPE for many recycling applications.

If pour spouts are added to a bottle they should allow for complete removal of product contents and be designed to leave virtually no product residue when the bottle is empty. If adhesives are used to affix attachments, they should be water-soluble or dispersible at temperatures between 60°C and 80°C in order to be removed in conventional washing and separation systems.

The use of attachments that contain metallic and other non-plastic components is discouraged and should be avoided.





# Polyethylene

Material specific guidelines

Table 3: HDPE Bottles

		YES	CONDITIONAL <sup>1</sup>	NO
BODY	Material	HDPE	PP <sup>2</sup>	PS
	Colour	Colourless / Coloured	Black inner layer	
	Barrier / Coatings		EVOH / PA (e.g. MXD6)	PVDC
	Additives			talc / CaCO <sub>3</sub> / other fillers that increase the density of HDPE above 0.995 g/cm <sup>3</sup>
CLOSURE	Caps	HDPE / LDPE / PP <sup>2</sup>		Steel / Aluminium / PS / PVC / Thermosets
	Liner	HDPE / LDPE / PE+EVA / PP		PS / PVC / EVA with aluminium
	Seals	PE / PP / OPP	Aluminium	PVC / Silicone
DECORATION	Direct Printing	production or expiry date		Other direct printing
	Labels	HDPE / MDPE / LDPE / LLDPE / PP or OPP <sup>2</sup> / PS (US only)	Paper <sup>3</sup> / PET / PETG / PS (except US)	PVC / Aluminium / Metallised labels
	Sleeves (incl. tamper resistance)	PE / PP <sup>2</sup>	Paper <sup>3</sup>	PVC / PS
	Glue <sup>4</sup>	No adhesive on body or water-soluble adhesive or alkali soluble adhesives (<80°C)		Adhesive not removed in water or alkali at 80°C
	Ink	EuPIA good manufacturing practices		Inks that bleed and dye wash- solution
OTHER COMPONENT			HDPE / LDPE / PP <sup>2</sup>	PVC / RFID / Non-plastic
NOTE	<p>The content may have an impact on the recycling. Packaging of products such as mineral oil, silicone or silicone based products, pesticides, herbicides, hazardous chemicals are normally refused. Often these will be marked with internationally recognised hazard symbols:</p>			

(1) Some materials / bottle components are recyclable under certain conditions. Please check with recyclers or recycling organisations.

(2) In Europe a total level of 6 - 10% PP is acceptable, depending on the end application for r-HDPE.

In the USA the total level of PP should be kept below 5%

(3) Acceptable provided firstly labels are attached using water soluble adhesives and are not coated in a manner that prevents separation and removal during reprocessing (see Labels & Adhesives section of General Guidelines for more details) and secondly they do not pulp in the wash tank. Paper labels that do not satisfy these criteria should be avoided.

(4) Ref. EUPR positive glue list

# 1. General

For efficient separation and removal in conventional density separation processes, parts of the packaging system that are not compatible with PVC should have a density < 1 g/cm<sup>3</sup>.

## 1.1. Material Combinations

The use of PET components of any kind on PVC bottles is undesirable and should be scrupulously avoided. Very small amounts of PET (in the parts per million range) can severely contaminate the recycle and make it useless for most applications. In addition, PET and PVC both sink (densities are similar and >1 g/cm<sup>3</sup>) and thus are very difficult to separate in conventional water-based density separation systems.



Material specific guidelines  
**PVC**

# 2. PVC Bottles

## 2.1. Closures

Plastic closures made from HDPE, LDPE or PP are preferred. The use of PET closures and closure liners is undesirable and should be scrupulously avoided.

## 2.2. Labels

The preferred label systems are those that incorporate the label on the closure, followed by shrink sleeve labels that require no adhesive. The use of PET should be scrupulously avoided.

## 2.3. Other Components

The use of other attachments on the bottle is discouraged but when required, HDPE and clear PVC should be used.



Table 4: PVC Bottles

		YES	CONDITIONAL <sup>1</sup>	NO
BODY	Material	PVC		
	Colour			
	Barrier / Coatings			
	Additives			
CLOSURE	Caps	PVC / HDPE / LDPE / PP / EVA	PU	PET / PS (density >1g/cm <sup>3</sup> ) Thermoset plastics / Aluminium / Steel
	Liner		EPS (density <1g/cm <sup>3</sup> )	PET
	Seals			
DECORATION	Direct printing			
	Labels	HDPE / MDPE / LDPE / LLDPE / PP / OPP / PVC / PVDC	Paper <sup>3</sup> / EPS	PET / PS / Metallised
	Sleeves (incl. tamper resistance)			
	Glue <sup>2</sup>			
	Ink			
OTHER COMPONENT	Inserts	HDPE / LDPE / PP Unpigmented PVC	PA (Nylon) / PC (Polycarbonate) PMMA (Acrylic) / EVA	PS / EPS / PU / Thermoset plastics

(1) Some materials / bottle components are recyclable under certain conditions. Please check with recyclers or recycling organisations.

(2) Ref. EUPR positive glue list

(3) Acceptable provided labels are attached using water soluble adhesives and are not coated in a manner that prevents separation and removal during reprocessing (see Labels & Adhesives section of General Guidelines for more details) and secondly they do not pulp in the wash tank. Paper labels that do not satisfy these criteria should be avoided.

# 1. General

For efficient separation and removal in conventional density separation processes, parts of the packaging system that are not compatible with PP should have a density > 1 g/cm<sup>3</sup>.

## 2. PP Bottles

### 2.1. Materials / Material Combinations

The use of unpigmented PP bottles is preferred to pigmented bottles as the recyclate from unpigmented bottles will have a greater value due to the larger number of potential applications.

Clarified PP is acceptable when bottles are shown to be compatible with end uses for recyclate.

The principal polymer contaminant of recovered PP is HDPE from bottles, closures and attachments. PP and HDPE are opaque and less dense than water and consequently difficult for reprocessors to separate. Since HDPE has a lower melting point (ca 130°C) than PP (160-170°C) the overall PP mix will be more tolerant to HDPE contamination than the converse.



Nonetheless, when designing packaging, it is recommended that PE levels are restricted to a maximum of 5% to avoid potential end use issues. This is in line with US recommendations. Higher levels may be possible but this would require the difficult task of investigating the likely effects on the total mix during recycling.

### 2.2. Barriers

Current PP recycling systems can tolerate the use of EVOH layers. Similarly MXD6 and other nylon-based barrier layers are tolerated, particularly if the layers are readily separated from the PP in conventional reclamation systems. In all such cases their content should be minimised to the greatest extent possible to maximise PP yield and reduce potential contamination and separation costs.

PVDC barriers should be avoided.

### 2.3. Closures / Closure liners

The use of closures that are unpigmented or the same colour as the bottle are desirable (although not essential). Foil safety seals that leave foil or remnants of the attaching adhesive on the PP bottle should be avoided.

### 2.4. Labelling

In applications using unpigmented PP, all direct printing other than date coding, either for product labelling or decoration, presently contaminates the recycled unpigmented PP in conventional reclamation systems.

### 2.5. Other components

Use of PVC components should be avoided as they can cause discolouration and malodour.



# Material specific guidelines Polypropylene

Table 5: PP Bottles

		YES	CONDITIONAL <sup>1</sup>	NO
BODY	Material	PP		
	Colour			
	Barrier / Coatings		EVOH / PA (incl. MXD6)	PVDC
	Additives		Clarifier <sup>3</sup>	
CLOSURE	Caps	HDPE / LDPE / PP	PVC	PS / Thermoset plastics / Aluminium / Steel
	Liner	HDPE / LDPE / PP	PVC / EVOH	PET / PS / Thermoset plastics
	Seals			
DECORATION	Direct Printing	Production or expiry date		Other direct printing
	Labels	HDPE / MDPE / LDPE / LLDPE PP / OPP / PS (US only)	PET / PS (except US) / Paper <sup>4</sup>	PVC / Metallised
	Sleeves (incl. tamper resistance)	PP / PE		PVC
	Glue <sup>2</sup>			
	Ink			
OTHER COMPONENT	Inserts	HDPE / LDPE / PP	PVC / EVA	PS / EPS / PU / PA (Nylon) PC (Polycarbonate) / PMMA (Acrylic) Thermoset plastics / Metallic

(1) Some materials / bottle components are recyclable under certain conditions. Please check with recyclers or recycling organisations.

(2) Ref. EUPR positive glue list

(3) Clarified PP is acceptable when bottles are shown to be compatible with end uses for recyclate

(4) Acceptable provided firstly labels are attached using water soluble adhesives and are not coated in a manner that prevents separation and removal during reprocessing (see Labels & Adhesives section of General Guidelines for more details) and secondly they do not pulp in the wash tank. Paper labels that do not satisfy these criteria should be avoided.

Mixed plastics is a term that covers all non-bottle plastic packaging sourced from the domestic waste stream and includes rigid and flexible plastic items of various polymer types and colours that are typically found in the household waste bin. It excludes plastic bottles and non-packaging items.

With an increasing range of materials being recovered in domestic waste recycling systems, mixed plastics packaging is one of the most visible remaining components of the domestic waste bin. Mixed plastics packaging is a significant component of the household waste stream and is likely to rise in the future<sup>19</sup>. In addition, for those countries in Europe that collect all packaging waste within their respective recovery schemes (e.g. Germany, Italy and Spain), the same fee scale is used for both rigid bottles and mixed plastics. Hence the manufacturers who have to pay the fees for mixed plastics packaging expect a progressively higher percentage of the material to be recycled. There is therefore a growing need to develop sustainable waste management options for non-bottle mixed plastics packaging in Europe and there are signs that plastic packaging collection streams in the USA are expanding beyond rigid bottles / jars into mixed plastics packaging for recycling.

The expectation is therefore that mixed plastics packaging recycling will become progressively more important into the future as a wider range of plastics are accepted in domestic recycling systems.

Sorting and handling issues are a particular challenge for mixed plastics, as films and mixed rigid plastics are historically difficult to separate into marketable fractions.

Where mixed plastics packaging is being recycled, typically the mixed plastics packaging is collected together with plastic bottles. Once collected, the flexible packaging is first separated from the rigid plastic packaging and then the bottles are extracted from the rigid mixed plastic components. The rigid mixed plastic component (pots, tubs and trays form the bulk of this packaging type) is generally then separated into a polyolefin stream (PE+PP or PE & PP separately) and a PET stream using near IR detectors.

While there are markets for all major individual polymer types once separated, there is an under developed market at the present time for a mixed plastics stream. The mixed polyolefin stream is often used to make for example insulation and furniture while the PET material is used in applications that can utilise lower quality compounded PET flake e.g. furniture.

Given the relative newness in mixed plastics recycling, guidelines for designers are currently limited. Nonetheless, this document includes some basic guidelines that designers can use to try and ensure that the potential of their mixed plastics for recycling is maximised. It must be appreciated that mixed plastics packaging recycling is very much in its infancy and designers cannot assume that their mixed plastic packaging will necessarily be recycled at this time. However, following these guidelines will further help with the development of this important but as yet relatively untapped resource stream.

## Further Guidelines for mixed plastics

### 1. General

The basic design principles for mixed plastics packaging are no different to those given in the general guidelines section and in the specific polymer sections for bottles. However, the processes used for the recycling of mixed plastics are not identical to those used for plastics bottle and hence exactly the same rules may not apply. This is likely to become particularly apparent in the future when more experience is gained with the recycling of various mixed plastics.

### 2. Rigid Mixed Packaging

#### 2.1. Material / Material combinations

As with rigid bottles, use of mono-materials or mixed materials of the same type are the materials of choice from a recycler's point of view for mixed plastics. Mixed plastics however very often require the use a variety of plastic materials to provide both the technical properties required and to satisfy user

needs. In the absence of any other specific guidance, designers should follow the recommendations provided for the corresponding polymer bottle material when designing a mixed plastic rigid container. Alternatively, components that were known to be readily separable could be used.

#### 2.2. Colour

Wherever possible use of dark rigid mixed plastics packaging (e.g. black, dark brown, and any heavily pigmented colour<sup>20</sup>) should be avoided as these remain invisible to IR detectors on black conveyor belts and thus will be rejected. In addition any black / dark material entering the mixed plastic recycling stream will further reduce the value of the recyclate.

#### 2.3. Contamination

Mixed plastics containers are generally lightweight. Product contamination can therefore represent a significant proportion by weight of the collected material (e.g. the weight of product residues in yoghurt pots can be as much or more than the weight of the container itself). Contamination lowers the efficiency of the recycling process as polymer weights are much less than weights of material collected and the residues themselves (often oily food) can interfere with the washing process. It is therefore important that containers are designed in such a way as to ensure levels of contamination are minimised as much as possible. This not only provides a benefit to recyclers, but also to the consumer. To further facilitate recycling, consumers / end-users should remove any plastic film, paper, cardboard and foil present and as much food residue as possible before putting the container out for collection.

As with bottles, any rigid mixed packaging used for DIY, garage or garden products should not be added to the recycling stream.

##### 2.3.1. PET

PET will be one of the first materials to tackle with respect to rigid mixed plastics recycling, especially PET trays / blisters as they represent a significant fraction by weight of the domestic mixed plastics waste stream. It is an area where expertise is only just beginning to be built up however and hence at present no specific guidelines on PET trays / blisters can be provided.

One particular immediate difficulty that will need to be faced is the widespread use of PET/PE multi-layers ( e.g. in the processed meat sector). As already indicated, use of mono-materials or mixed materials of the same type are the materials of choice from a recycler's point of view. Hence the current efforts by some producers to switch from PET/PE blends to monolayer PET for trays / blisters should further facilitate the recycling of this mixed plastic.

As with other PET packaging formats, it is vitally important that contamination by PVC is avoided. PVC trays and blisters represent an important potential contaminant of the PET tray and blister stream and every effort needs to be made to try and ensure that such contamination is avoided either at through design and / or at the recycling stage.

##### 2.3.2. PE

###### Tubs / Dishes

- Tubs and dishes are often made of injection grade HDPE, exhibiting higher melt flow rates than blow molding grade HDPE. Mixing the two types of HDPE together decreases the value of the mixture. Do not mix HDPE bottles with HDPE tubs or dishes.
- In principle aluminium lids are acceptable on PE, especially peel-off ones. Adhesive should stay with the aluminium lid.
- Tubs that have a clear or colourless body and where the information is presented on the lid are particularly suitable for recycling.
- Direct printing is acceptable provided attention is paid to ink types to avoid interference with the quality of regranulate.
- Excessive paper content can cause issues during recycling and thus use of paper labels is less desirable. If used, they should be lightweight and cover only a minor area of the container. Paper labels should not pulp in a hot caustic washing step.

###### Tubes

- Cap and tube should be manufactured from the same type



<sup>19</sup> For example, there is currently approximately 1 million tonnes of domestic mixed plastics packaging waste arising in the UK each year and this tonnage is growing.

<sup>20</sup> Opaque (white) also causes problems with NIR detectors.

of plastic and ideally from the same polymer (in this case HDPE). An elevated percentage of PP lowers the quality of the recycled plastic.

- Direct printing is acceptable for marking tubes provided the printing is in compliance with the EuPIA Exclusion list. Paper labels also can be used, provided they are easily removed in water and leave no adhesive residue that is difficult to remove.

### 2.3.3. PP

PP will be one of the first polymers to develop in terms of recycling opportunities on a large scale after bottles.

#### Tubs / Dishes / Trays

- In principle aluminium lids are acceptable, especially peel-off ones. Adhesive should stay with the aluminium lid.
- Tubs that have a clear or colourless body and where the information is presented on the lid are particularly suitable for recycling.
- Direct printing is acceptable provided attention is paid to ink types to avoid interference with quality of regranulate.
- Excessive paper content can cause issues during recycling and thus use of paper labels is less desirable. If used, they should be lightweight and cover only a minor area of the container. Paper labels should not pulp in a hot caustic washing step.

#### Tubes

- Cap and tube should be manufactured from the same type of material and ideally from the same polymer (in this case both from PP).
- Direct printing is acceptable for marking tubes provided the printing is in compliance with the EuPIA Exclusion list. Paper labels also can be used, provided they are easily removed in water and leave no adhesive residue that is difficult to remove.

### 2.3.4. PS

#### Tubs / Dishes / Trays

- Applications using clear, colourless polystyrene have the highest recycling value. Therefore use of unpigmented containers is preferred. Coloured transparent containers are acceptable however, but their recyclability and the value of the recyclate are reduced.
- In principle aluminium lids are acceptable on PS, especially peel-off ones.
- Tubs that have a clear or colourless body and where the information is presented on the lid are particularly suitable for recycling.
- Direct printing is acceptable provided attention is paid to ink types to avoid interference with quality of regranulate.
- Excessive paper content can cause issues during recycling and thus use of paper labels is less desirable. If used, they should be lightweight and cover only a minor area of the container.

## 3. Film

### 3.1. Material / Material combinations

As with rigid bottles and mixed plastics, homogeneous films can be recycled optimally. Use of mono-materials or mixed materials of the same type are the materials of choice from a recycler's point of view and combinations with a different type of plastic of similar density should be avoided wherever possible.

Mixed plastics film very often requires the use a variety of plastic materials, however, to provide both the technical properties required and to satisfy user needs. Recognising this need, and in the absence of any other specific guidance, designers should follow the recommendations provided for the corresponding polymer bottle material. In the case of films, however, this is less important as some film recyclate is used in applications that have a more tolerant specification e.g. furniture, bin liners etc. In these cases plastic film users can feel less restricted to use material combinations in the CONDITIONAL categories than with rigid containers. Combinations in the NO category should still be avoided.

Use of aluminum foil in bags for frozen food should be avoided.

### 3.2. Labels

Labels manufactured from materials that float in water while the film sinks (e.g. PET) or vice versa and attached with water-soluble adhesive are acceptable. Paper labels also can be used, provided they too are easily removed in water and leave no adhesive residue that is difficult to remove and do not reduce to pulp in the washing process.



Table 6: PS Tubs / Dishes / Trays

		YES	CONDITIONAL <sup>1</sup>	NO
CONTAINER		PS HIPS / PS	?	Multi-layer material (unless based on PS with polymers of the same type in limited quantities)
	LID	Aluminium foil Metallised OPET Metallised OPP PBT / PS PET / light paper PS PS with PE insert PS with EVA insert OPS		PE PP
DECORATION	Direct Printing	Acceptable <sup>2</sup>		
	Labels	Paper <sup>3</sup> (lightweight) PE PP / OPP PS (in mould) OPS EPS		Paper (heavy) PET PVC

(1) Some materials / bottle components are recyclable under certain conditions. Please check with recyclers or recycling organisations.

(2) Provided that the updated EuPIA exclusion list for printing inks and related products is followed and inks that would dye the wash solution avoided.

(3) Acceptable provided they are attached using water soluble adhesives and are not coated in a manner that prevents separation and removal during reprocessing (see Label Adhesives section of General Guidelines for more details)

# Bioplastics

In response to the global focus on climate change and sustainability, there is a growing interest in the use of bioplastics in packaging applications. In Europe, consideration has been given by individual member states to promote the use of this type of packaging: Germany currently has a derogation from recovery fees to provide time for a suitable waste infrastructure to be developed and France had considered introducing a law to promote the use of bioplastic carrier bags. In the Netherlands, packaging made from EN certified materials also enjoy a lower packaging tax tariff. Public opinion also favours biodegradability and Retailers (e.g. Walmart in the USA and Sainsburys in the UK) as well as brand owners (Primeal France, Sant'Anna water Italy) are beginning themselves to respond to this preference.

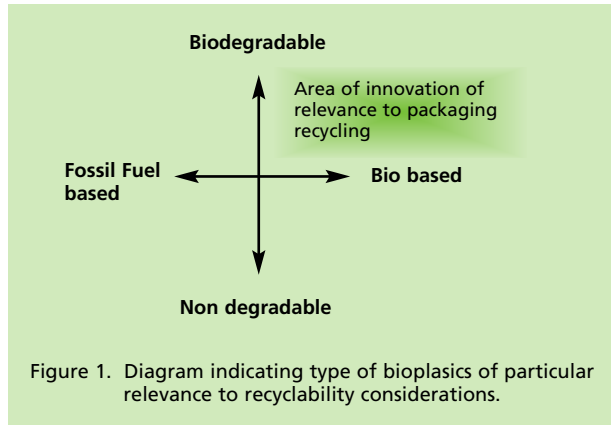
Bioplastics are not a single class of polymer but rather a family of products which can vary considerably one from the other. Whilst a generally recognised definition of the concept does not exist, European Bioplastics, like many other associations, regards bioplastics as having two differentiated classes:

- Plastics based on renewable resources
- Biodegradable polymers which meet all criteria of scientifically recognised norms for biodegradability and compostability of plastics and plastic products (EN13432 in Europe, D6400-04 in the USA and more recently ISO 17088).

In both classes, a high percentage of renewable resources is used in the polymer production. Whereas products from the first group do not necessarily have to be biodegradable or compostable, those from the second group do not necessarily have to be based on renewable materials in order to meet the EN 13432 / D6400-04 / ISO 17088 criteria.

Bioplastics offer the potential to provide an infinitely renewable source of packaging raw materials and biodegradable bioplastics an additional recovery route, namely organic recycling. In addition, if enough products enter the market, recycling (in some cases chemical recycling i.e. chemical depolymerisation to monomer) can be considered an option for such homogeneous recovery streams. Also, both types of bioplastic can be incinerated with energy recovery with minimal net CO<sub>2</sub> emissions: the CO<sub>2</sub> produced simply reversing the photochemical uptake of carbon from the atmosphere by the plants during the cultivation of the raw materials.

Such materials are not without their own potential issues. Competition with land for agricultural use and use of fossil fuels during production are two of the issues currently under debate at present.



Many bioplastics are biodegradable, however this is not an inherent requirement. Equally while most conventional plastics (e.g. polyolefins, PET etc.) are neither biodegradable nor compostable there are some synthetic polymers which are certified biodegradable.

In the context of designing for recyclability, conventional polymers derived from either natural resources or fossil fuels will behave no differently from each other and thus need no special mention in this context. Bio-based polymers that are relatively new to the packaging market do require special mention. These polymers in addition are generally biodegradable and thus the focus of discussion in the context of the current document is the top right section of Figure 1.

There are currently three bio-based polymer types on the market: starch materials, polylactic acid (PLA, polyester) and cellulose materials<sup>21</sup> It is also worth noting that although renewable raw materials dominate the production of current bioplastics, many bioplastics are however mixes or blends containing synthetic components. Synthetic polymer types and additives are frequently used, albeit in small quantities, to improve the functional properties of the finished product and to expand the range of applications. Use of this material for film and tray applications predominates (especially for packaging organic produce) but bottle applications are also found on the market.

The pro's and con's as to whether a biobased or fossil fuel derived plastic should be chosen for a particular application is complex and certainly

<sup>21</sup>Polyhydroxy fatty acids (PHA) are likely to soon become a fourth class as a succession of companies have announced they will set up production facilities.

well beyond the scope of the current document. What is pertinent is the fact that compostable packaging based on renewable materials can now be found on the shelves of almost all European supermarkets and in many other countries of the world. Of particular importance in the current context is their use to package fresh foods and hygiene products. It is therefore opportune to highlight the implications of the use of these materials on packaging recycling. Two aspects have to be considered, firstly the recyclability of the materials themselves and secondly, the effect the use of bioplastics might have on existing material (in this case plastic) commercial recycling streams.

## Recyclability of bioplastics

As indicated earlier in this document, it should not be automatically assumed that every piece of packaging necessarily should be recycled and bioplastics are no different. Incineration with energy recovery and, in many cases, organic recovery may be a more attractive and environmentally beneficial option. Organic (food) waste, as a result of the landfill directive, will need to be diverted from landfills and will ideally be processed in industrial composting units or turned into energy by anaerobic digestion. Such a waste system also would be able to process most bioplastics, which would represent a small fraction compared to the general organic waste.

Packaging recovery schemes are often very different across the EU. The reason being that waste management systems are optimised to take account of local infrastructures for collection and recycling, local and regional regulations, the total volume on the market available and the composition of waste streams. Most countries have set up systems to recover and recycle plastic bottles, but for most other types of packaging, the results are more fragmented and not always very well developed.

In many cases, mixed fossil-based plastic waste fractions are being incinerated and by doing so, energy is being recovered. Packaging from bioplastics that would end up in these waste fractions (e.g. films) will also be incinerated with energy recovery, but will generate renewable energy instead, since the carbon is renewable resource based.

Bioplastics can be recycled but should not be mixed with traditional plastics as they are not compatible with each other. In addition, incompatibilities between different types of bioplastics, as with as traditional polymers,

require them to be sorted by type before being recycled. However, use of bioplastics in packaging is still in its infancy and applications still evolving. For this reason market volumes have not yet reached sufficient critical mass for the recycling of individual bioplastic packaging streams (e.g. PLA) to be considered commercially viable or for current waste management systems that are optimized to recycle conventional plastics (PE, PET etc.) to be modified. Over time, recycling may become the best option for certain bioplastics once critical volumes are achieved in the waste stream and where a homogeneous stream separate from conventional plastic bottle streams / other bioplastics can be organised.

## Effect of bioplastics in current plastic waste streams

Mixing of bioplastics with traditional plastics can affect recycling. At present, such issues are relatively limited because of the current low market penetration of bioplastics but given the growing interest in such materials then this situation may change sooner rather than later. Bottle recyclers often have robust systems in place to sort contaminants out from current waste streams. As volumes grow, it will become more effective to start to identify and recover bioplastics from these streams.

The risks associated during this transition period with existing recovery schemes should be monitored. It will be important for users of bioplastics packaging to be able to anticipate which conventional material stream a bioplastic packaging application is likely to go into if not separated out. An assessment of the relative compatibility of the bioplastic with the material stream (from knowledge of material compatibilities and anticipated total levels in waste stream) would then allow any risk of undermining the conventional recycling stream to be assessed. Such monitoring and analysis would be best achieved through close collaboration of bioplastic producers, packaging user and recyclers.

Consideration should be given to developing a separate infrastructure for the collection of the bioplastic where risks are foreseen and sufficient market uptake achieved. An alternative option which could be used regardless of market volume but where a risk is anticipated, would be to develop a mechanism to ensure that the levels of the bioplastic reaching the conventional stream are kept acceptably low through extraction of the bioplastic from the conventional material stream using either manual or automatic sortation.

# Appendix

## Process to generate document

Development of the updated document and management of the process was again guided by a small Steering Group, the composition of which is given in the following table:

**Tables 7: Composition of Steering Group**

Arno Melchior	Reckitt Benckiser
Jim Armstrong	Wellman Recycling
Roger Baynham	Philip Tyler Polymers
Keith Marriage	GlaxoSmithKline
Stuart Small	British Soft Drinks Association
John Simmons	Recoup
Steve Anderson	SSA Associates

As with the first version, a program of engagement with experts and key industry associations was undertaken to obtain broad document acceptance.

The original document (version 1, 2006) was compiled by referring to information current at the time of preparation issued by national organisations within Europe and by associations both in Europe and the USA. The current update makes use of the most up to date versions available of these excellent documents, referenced in Appendix 11,

As before, this project has reviewed some areas where different currently published guidelines appear to offer conflicting advice. A number of national, European and US organisations dealing with plastic packaging were then asked to review the content of the draft document and help clarify and resolve areas where conflicting advice had been identified. Finally, the project and subsequent document were discussed with a number of additional organisations dealing with packaging on an ongoing basis throughout the project to help ensure that the document had the widest possible general support.

The organisations listed below, were consulted during the production of the guidelines:

APR	Association of Postconsumer Plastic Recyclers
BSDA	The British Soft Drinks Association
COTREP	Comité Technique de Recyclage des Emballages Plastiques
EPBP	European PET Bottle Platform
EPRO	European Association of Plastics Recycling and Recovery Organisations
EuPR	European Plastic Recyclers
NAPCOR	National Association for PET Container Resources
Plastics Europe	Association of Plastic Manufacturers
PETCORE	PET Container Recycling Europe
Recoup	Recycling of Used Plastics Limited

The guidelines have been supported by the organisations listed on page 45.



## Recycling of plastic packaging

The development of collection, sorting and reprocessing technology and its techniques is changing rapidly. The following information will provide the reader with a useful picture of today's practices. As time goes by it may be useful to check if any significant changes have taken place to these practices and this can be done via the Recoup web site.

Recycling of plastics has rapidly developed over the last ten years, especially in Europe as a result of the coming into force of the Packaging and Packaging Waste Directive, and has become widespread and progressively more sophisticated.

Used domestic packaging and used commercial & industrial packaging are both recycled. Separate waste collection streams have existed for some time for commercial & industrial waste as recycling of such materials is traditionally more commercially favourable (e.g. cleaner materials, bulk collection). In terms of domestic plastic waste recycling, which is the focus of the current document, the science and processes for recycling have been designed for containers in general and bottles in particular. Hence the recycling systems and their value are most applicable to 'bottles' in their widest sense.

Six main types of plastic are found in the domestic waste stream: PET, HDPE, PVC, LDPE, PP and PS. All bottles of a given type of polymer are usually compatible and so may be mechanically recycled together. Technical incompatibilities between a number of these different polymers, however,

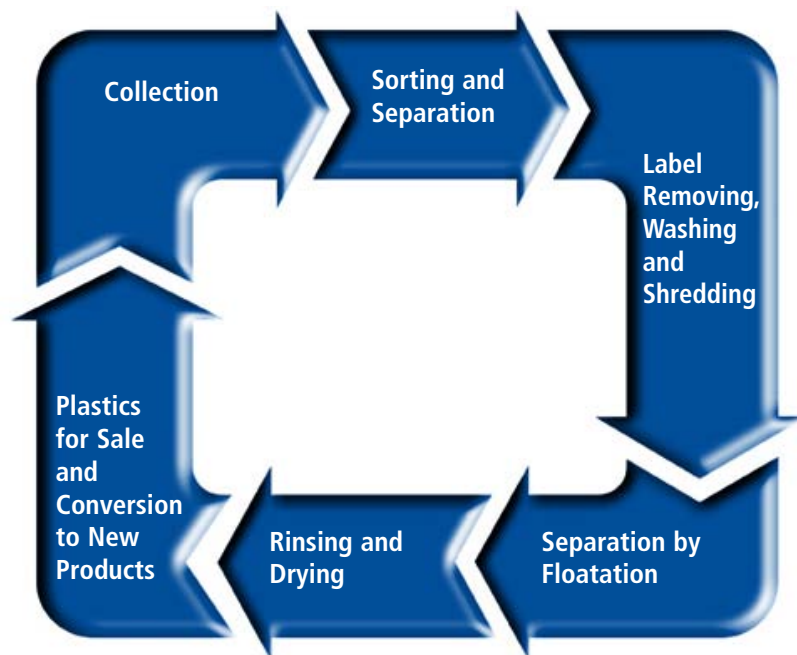
prevent them being directly mixed and mechanically recycled as high specification products. However, they can be readily separated, provided the simple guidelines given in this document are followed.

There are a wide variety of collection methods used to receive recyclable materials from the householder. Most of these methods identify particular material types and products that should be deposited. These products are usually newspaper and magazines, cardboard, glass containers, steel and aluminium cans and plastic bottles. Over the past 20 years in the UK there has been a significant growth in the use of 'kerbside collection' systems to realise higher material recovery, and fewer authorities now rely solely on collecting recyclables using 'Bring Banks'.

There are two main routes for the recycling of plastics packaging waste: (1) Mechanical recycling where the recovered material is used directly for the same or a new application and (2) Feedstock recycling. Mechanical recycling dominates the plastic recycling industry at this time and this process requires clean sorted polymer material to produce high specification products. It is also worth noting that the sorting of co-mingled recyclable materials is, in general, labour intensive, unless investment is made in highly automated equipment. Mixed and contaminated plastic waste may also be recycled to produce lower specification material but the markets for this material are much more limited.

A typical plastics mechanical recycling process involves several distinct steps and these are indicated in the diagram below.

**Figure 1: Typical steps in the mechanical recycling of plastic**



During 2008 a notable development occurred in the sorting of mixed plastics packaging in the UK. This was the establishment of a new type of sorting facility solely focused on separating the main polymers and colours arising from the collection of plastic packaging from kerbside and brings schemes. These new facilities now identified as Plastics Reclamation Facilities (PRFs) accept baled mixed plastics from MRFs and then take them through a sophisticated sorting process where the main polymer types and colours are identified and sorted. These facilities then bale the sorted plastics before selling the material to reprocessors who will re-inspect the material, wash, granulate and often re-extrude the plastics materials to provide a high quality material which can then be used to manufacture new products. The two PRFs recently commissioned in the UK are progressing plans to incorporate, on the same site as the PRF, a plastics reprocessing facility.

Packaging specification and collection scheme design potentially can affect the efficiency of each of these stages, but the efficiency of the sorting and separation and the separation by flotation (density) stages are the most sensitive to the choice of packaging components. Designs that cause serious issues at any of these stages will cause processing inefficiencies that could risk batch rejection and seriously undermine the profitability of the process. This will result in high cost or lower quality material that will have limited end-use markets. In addition, it will result in higher levy fees paid by companies to recovery organisations charged with the responsibility of recycling the legally required amount of plastic packaging waste on their behalf.

The specification and quality standards required to be met by the reprocessor reflect the standards required by the convertor who use the reprocessed materials to manufacture new products made from recycled materials. As a result the reprocessor needs to identify to those supplying the collected plastics packaging, from both kerbside and bring schemes, a specification which identifies which materials can be accepted and which materials would not be accepted. Similarly these requirements need to be translated into instructions to the householder to help them identify only those materials that should be collected and which will be recycled. It is important that only those materials that can be recycled are collected. Non-requested materials which could be potentially dangerous,

contaminate or add unnecessary costs to recycling processes and should clearly not be collected.

Many countries still rely heavily on the manual sorting of whole plastic bottles by visual inspection. However automatic bottle sorting is becoming more widespread both within Europe and especially within the USA, where the larger Material Reclamation Facilities have throughputs sufficient to offset the capital cost of the equipment. Manual bottle sorting is based primarily on the physical characteristics of the bottle (e.g. shape, colour, product recognition, and parison marks) and experience. However this method can lead to inaccurate identification and separation due to human error or distorted containers. In addition, complications arise when bottles of the same design are made using different polymer types. Although most plastic bottles carry a Material Identification code (see Appendix 8), this coding system has limited value to sorting personnel. Manual sort rates are typically 1200+ bottles/hour. Thus sorters have less than three seconds to pick up, identify and sort the bottle. This precludes the looking for the code on every bottle. Automatic sortation equipment utilises a variety of methods including FTIR spectroscopy, X-ray fluorescence spectroscopy (PVC) and optical methods (colour) for polymer identification and "positive" separation into separate polymer resin streams. Typical automatic sort rates are up to 40,000 bottles/hour or 11 bottles per second. Although not without its limitations, auto-sorting greatly improves the quality and efficiency of the separation process. Automatic sorting can also be used with polymer flake but in this case it is only used as a "polishing" step to remove low levels of identifiable materials.

Packaging design should facilitate the separation of non-compatible polymers and avoid the risk of their being left unseparated by visual or mechanical recognition systems.

During the label removing / washing / shredding stages, bottles/film are reduced to flake (5-10 mm). The intense friction and cutting action in the presence of circulating water provides the first washing stage, removing most labels and residual contents. Hot water, alkali solution and detergents are then frequently used during further washing stages to remove more difficult to separate contaminants such as residual labels and adhesives.

Density based sorting, such as sink/float tanks, hydro-cyclones and air classification separate contaminants on the basis of density. Use of float tanks is very common (e.g. PET recycling) as they are much simpler and cheaper. The ability to separate materials is much more limited however, and restricted to two types, namely those that sink and those that float in water. Thus any mix of plastic types that sink together / float together in water are not capable of being separated. The key density difference is now not so much that between the polymers themselves than the density difference between the individual polymer and water. The density ranges of plastics commonly used for packaging are given in table 8, Appendix 6. This table provides intrinsic plastic densities and also indicates how the polymer behaves in a float tank.

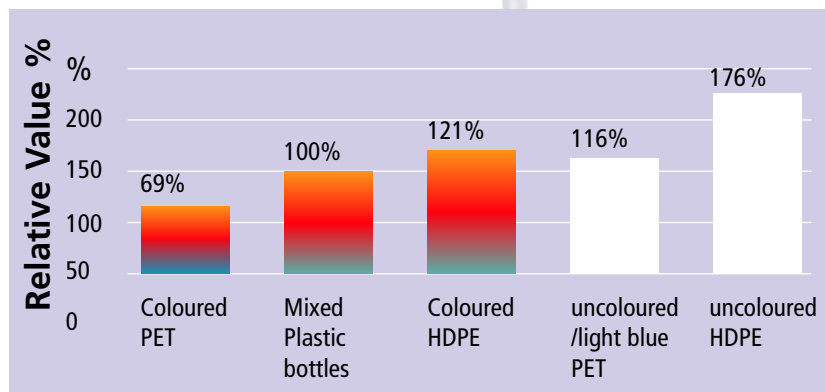
The guidelines provided in this document are driven by the requirements of the mechanical recycling process. In the future some of the current restrictions, particularly with PET, may be relaxed as feedstock recycling plants come into commercial operation.

## Markets for recovered material

The value of the recovered material is closely related to its quality. The following figure gives an indication of the relative value of plastic bottle materials typically marketed.<sup>23</sup>

**Figure2 : Recovered Plastics - Relative value of different grades**

The diagram right clearly demonstrates the significantly higher value of the secondary material if it can be separated into individual polymeric types and the reduced value of pigmented plastics.



## Plastic Recycling Levels

The most recent data from European Member States<sup>22</sup> indicates that within the EU-27 (and including Norway) ca 3.9 million tonnes of the 15.0 million tonnes of plastic packaging placed on the market was recycled in 2006. This corresponds to an average recycling rate of ca 26%.

US EPA figures<sup>24</sup> indicate that the overall recycling rate in 2006 for all plastic packaging coming from municipal solid waste was 10.9%. 577,000 tonnes of this was post-consumer PET plastic packaging, corresponding to a recycling rate of 20.3% for this polymer resin.



Above. AWS plastic reprocessing facility, UK.

<sup>22</sup>EUROSTAT Packaging Waste Data 2006 (updated 2008)

<sup>23</sup>Prices for recovered material fluctuate and were especially volatile at the time of preparation of the current update (Q4/08). The relative values quoted were derived from monthly price information figures quoted in Letsrecycle.com and have been averaged over the three year period January 2006- November 2008.

<sup>24</sup>Municipal Solid Waste in the United States, US EPA, 2006

## Legislative and Environmental Climate

Packaging has a very negative perception with consumers and environmentalists. It is perceived to be a waste of resources and a significant contributor to the growing levels of waste<sup>25</sup>. In addition it is often also linked to litter issues. Politicians are very aware of this with the result that pressure has been and continues to be applied on packaging through the introduction of legislation in Europe, the USA, Japan and other countries around the world. The general approach to packaging legislation traditionally has been very much 'command and control' for example regulating how much packaging needs to be recovered, recycled, what percentage of packaging needs to be refillable etc. rather than dictating the overall desired environmental goal and leaving industry with the flexibility of deciding how this might best be achieved. Encouragingly, less heavy-handed incentive-based mechanisms (e.g. emissions trading) are beginning to be looked upon more favourably appear to work well.

In addition, legislators and environmentalists continue to encourage the application of a strict waste hierarchy where the order of priorities is:

**Prevention > Reuse > Recycling > Energy recovery > Landfill**

This is exemplified in the recent review of the Waste Framework Directive in Europe. The revised Directive requires that this waste hierarchy be applied as a *priority in waste prevention and management legislation and policy*. Such a rigid interpretation is not supported by Industry<sup>26</sup>. This has been recognised at least to some extent within the recent review of the European Waste Framework Directive as the revised Directive allows a departure from this hierarchy when justified by life cycle thinking on the overall impact of generation and management of specific waste streams. Regardless of technical correctness however, recycling is seen by many as the most important recovery route and therefore the one that should take precedence. Indeed one of the stated aims of the revised European Waste Framework Directive is to help move the EU closer to a recycling society with a high level of resource efficiency. To promote this Article 11 requires Member States to take measures to promote high

quality recycling and sets for 2020 a combined minimum overall reuse / recycling target of 50% for key material waste streams, of which plastic is one, arising from household and other similar wastes.

Pressure is progressively being applied to packaging through the introduction of legislation in Europe, the USA, Japan and other countries around the world. Europe has one of the earliest and certainly the most comprehensive packaging legislation, namely the Packaging and Packaging Waste Directive. This legislation is also acting as a model for many other parts of the world.

The European Packaging and Packaging Waste Directive (PPWD) sets the current framework for National packaging legislation across the European Union (see Appendix 4 for more detail) and acts as a model for many other parts of the world. The basic legislation (Directive 94/62/EC) came into force in 1994 and required amongst other things, that by 2001 Member States achieve packaging recovery levels of 50-65% and recycling levels of 25-45%. In addition, no individual material (e.g. plastic) was to have a recycling rate <15%. The revision of this legislation in 2004 (Directive 2004/12/EC) has further increased the recovery and recycling targets to >60% and 55-80%, respectively and by so doing has increased the relative importance of recycling over general recovery. In addition, differentiated material specific recycling targets were introduced with the level set for plastic being a minimum of 22.5%. The Directive also mandates that packaging must satisfy certain essential requirements, one of which is that any packaging being put on the market must be recoverable (see Appendix 4 for further details). Recovery can be by recycling, energy recovery or organic recovery. However as indicated above and despite what the legislation allows, consumers, environmentalists and politicians consider recycling as the preferred recovery route.

The European Packaging and Packaging Waste Directive has been followed by European directives for other products (e.g. End of Life Vehicles, Waste Electrical and Electronic Equipment) using a similar approach.

<sup>25</sup> While packaging is a significant fraction of household waste (20-25%), domestic waste makes up <20% of waste sent to final disposal. Hence packaging waste represents <5% of waste in a landfill.

<sup>26</sup> Whilst Industry believes there should be a priority on using the minimum amounts of packaging for purpose and subsequently preventing as much used packaging as possible going to final disposal (generally landfill), the relative merits of reuse and the various recovery options very much depend on local circumstances. Industry therefore wants legislation to accommodate this by allowing some flexibility in approach to allow tailoring to suit local conditions.

In 2000, the European Union adopted a revised programme for the environment up to 2010. This, the Sixth Environmental Action Program (6EAP), established four environmental priorities, one of which included preserving natural resources and managing waste. The thematic strategy on the Sustainable Use of Natural Resources and the thematic strategy on Prevention and Recycling of Waste were established to progress this priority.

At that time, Integrated Product Policy (IPP) was seen as an important tool towards aiding the objectives of the 6th Environmental Action Programme (6EAP). The original objective of IPP was to promote the environmental performance (eco-efficiency) of a broad range of products through their life cycle and to stimulate demand for greener products. Subsequently, with concerns over European competitiveness, this was modified to reducing the environmental impact from products throughout their life cycle, harnessing, where possible, a market-driven approach, within which competitiveness concerns are integrated. In recognition of the additional importance of tackling consumption if the goal of sustainability is ever to be attained, the priority of the European Commission has now moved to Sustainable Consumption and Production. The earlier thinking and work carried out within IPP and the Thematic Strategies has not been lost however, but rather integrated into this new and broader policy framework.

While the action plan is still being developed, it is clear that this strategic policy approach encouragingly is embracing the more holistic concept of life cycle thinking and seeks to better integrate economic, social and environmental aspects. The policy developers' thinking is thus beginning to move closer to that of Industry giving hope that in the future a more holistic approach to policy will evolve.

Regardless of how policy progresses into the future it is clear that packaging recycling targets will remain in Europe for the foreseeable future. Even with the introduction of new and broader policies derived from the Sustainable Consumption and Production Action Plan it is likely that existing targets will be integrated into any new framework rather than removed, to ensure that the current recycling achievements with packaging are maintained and social and political issues avoided as far as possible.



## Packaging and Packaging Waste Directive (Directive 94/62/EC)

The European Packaging and Packaging Waste Directive sets the current framework for national legislation across the European Union and is progressively being used as the legislative model in other countries across the world. The basic legislation (Directive 94/62/EC) came into force on December 20, 1994 and was updated in 2004 (Directive 2004/12/EC).

### Scope and Aims

The European Packaging and Packaging Waste Directive (94/62/EC) covers all packaging placed on market within EU i.e. all household, commercial and industrial packaging waste with only minor exceptions (e.g. hazardous household packaging).

The stated aims are twofold:

- To bring national measures closer together and remove obstacles to trade such that packaging and packaged goods can circulate freely throughout the European Union.
- To minimise the environmental impact of packaging by reducing the amount of waste going to final disposal by promoting minimisation, reuse, recycling and other forms of recovery of packaging.

Like any other European Union Directive, the Packaging and Packaging Waste Directive is not directly binding legislation. It is an instruction to Member States to transpose it into their national law and to take the action required to ensure that its provisions are complied with. Individual companies are simply responsible for complying with whatever legal requirements are laid down at national level. In addition, it is a 'New Approach' directive and

therefore instead of being very precise and requiring Member States simply to translate it into national law, 94/62/EC is a framework directive that provides room for interpretation by Member States.

### Main requirements

The directive requires Member States to:

#### 1) Set up systems for return / collection of used packaging

The Directive requires Member States to take the necessary measures, covering the whole of their territory, to ensure that systems are set up for the return or collection of used packaging, so that the notified national packaging material recovery and recycling targets are achieved. It is up to national governments to decide what legislation is necessary; industry then has some freedom to decide how to structure and fund any recovery organisations set up to co-ordinate efforts. Companies will generally have a choice between joining a collective organisation that will take over their legal responsibilities or choosing direct compliance with the legal requirements.



## II) Achieve recovery and recycling targets

Member States need to set and achieve recovery and recycling targets within a defined range set out in the Directive. The targets currently in force (which represent an increase over those originally set out in Directive 94/62/EC) are given in Directive 2004/12/EC. Targets (by weight) to be achieved by 31 December 2008 are;

- Minimum of 60% packaging waste recovery
- 55-80% packaging recycled
- individual material recycling rates of
  - 60% glass
  - 60% paper and board
  - 50% metals
  - 22.5% for plastics
  - 15% for wood

After a review of the implementation and effectiveness of the directive in 2005/2006 the commission decided against any increases in these targets at the present time and hence they remain currently in force

Due to their special geography and infrastructure, Ireland, Greece and Portugal have been given a derogation to reach these targets by 2011. Similarly the ten new Member States that joined the European Union in 2004 and the two new Member States that joined in 2007 have been granted a further derogation in time to achieve these targets, the dates being set out in Directive 2005/20/EC and the 2005 Treaty of Accession, respectively.

“Recycling” for plastics exclusively counts material that is recycled back into plastics. “Recovery” includes all forms of recycling (material recycling, feedstock recycling and composting) plus energy recovery. Member States had to adopt national legislation to ensure that these targets are met.

Individual Member States can set targets beyond those indicated within the Directive, provided they do not distort the internal market and do not hinder compliance by other Member States with the Directive. The Commission and Member States have to be notified and agree, however, to any such proposals.

## III) Set up databases to provide all necessary information at national level.

The reporting of all packaging placed on the market, the quantity of packaging waste arising and recovered and the overall totals for material (i.e. glass, plastic, paper & fibreboard, metal and wood), recycling and recovery within Member States are mandatory. The split-up of plastics (PET, PE, PVC, PP, PS, others), metals (steel, aluminium) and the reporting of composites is voluntary. Composites can be classified according to the predominant material or separately specified.

Reporting of all packaging placed on the market within a member state is mandatory but reporting of reusable packaging is voluntary.

## IV) Ensure packaging complies with 'essential requirements'

Under the “New Approach”, the EU institutions speed up agreement on technical harmonisation issues by agreeing “Essential Requirements” which define the results to be attained and the risks to be dealt with, and delegate to CEN (the European Committee for Standardization) or CENELEC (the European Committee for Electrotechnical Standardization) the task of specifying the technical solutions needed. Member States are required (article 9) to ensure that packaging placed on the market complies with the essential requirements defined in the Directive.

Annex II to Directive 94/62/EC lays down the Essential Requirements that all packaging placed on the market within the European Economic Area<sup>27</sup> must comply with. These Essential Requirements can be summarised as follows:

- **Packaging weight and volume must be minimised to the amount needed for safety and acceptance of the packed product;**
- **Noxious and other hazardous constituents of packaging must have minimum impact on the environment at end of life; and**
- **Packaging must be suitable for material recycling and /or energy recovery and /or composting, or for reuse if reuse is intended.**



<sup>27</sup> The EU Member States plus Iceland, Liechtenstein and Norway.

The EU Commission mandated CEN to draw up a set of standards<sup>28</sup> on packaging prevention, reuse, material recovery, energy recovery and organic recovery. These were initially developed in 2000 but needed to be revised to further meet the requirements of the Commission and the Member States. The updated versions were adopted in 2004. With this latter update, an additional umbrella standard that explains the interlinks between the other standards was included.

Use of the standards is voluntary, but the Packaging and Packaging Waste Directive provides that there is a presumption of conformity with the Essential Requirements when packaging has been produced in accordance with harmonized standards whose references have been published in the Official Journal of the European Communities.

On 19 February 2005 the Commission published the references to the full set of standards in the Official Journal as recognition of their status as “harmonised standards”. This means that packaging which complies with the standards is deemed to be in conformity with the Essential Requirements, and cannot be denied access to any country in the European Economic Area on grounds of non-conformity with the Directive. Adoption of these harmonised standards also means that the burden of proof now resides with the enforcement authorities - they need to prove that packaging has not been produced in conformity with the relevant standards. Hence whilst the use of the CEN standards to show compliance is not mandatory and companies are allowed to use other methods to demonstrate compliance<sup>29</sup>, there are major benefits to be had by using the CEN standards approach.

In addition, adoption of the CEN management (checklist) approach ensures that packaging designers and specifiers keep potential environmental improvements under continuous scrutiny, as well as giving added value in developing the European Single Market for packaging and packaged goods.

The standard on material recycling (EN13430) requires that:

- A certain percentage of the packaging materials can be claimed to be recyclable
- A declaration is made of the percentage by weight of the functional unit<sup>30</sup> available for recycling and the identification of the intended material recycling stream(s)
- A written statement of compliance is prepared

The annexes in the standard identify the criteria that need to be considered when assessing the recyclability of packaging.

These include:

- Consideration of aspects significant for the recycling of the materials from which it is produced
- Control of the selection of raw materials to ensure that the recycling processes are not negatively affected.
- Ensure that the design of packaging makes use of materials and combinations of materials which are compatible with known, relevant and industrially available recycling technologies

These guidelines provide a useful aid towards satisfying the requirements of this standard.

Up to now, only three Member States (France, Czech Republic and the UK) have an enforcement regime in place for the Essential Requirements legislation. France and the UK have been enforcing the Essential Requirements since the late 1990s and have adopted detailed regulations explaining what companies must do to comply. The other Member States have done no more than transpose the text of the Essential Requirements into their National legislation more or less word-for-word with no indication of how they should be enforced. It had been anticipated that more Member States would start to enforce the legislation once harmonised standards became available and the Commission’s progress report on implementation of the Directive which included an evaluation of the effectiveness, implementation and enforcement of the Essential

<sup>28</sup> EN13427:2004 Packaging - requirements for the use of European Standards in the field of packaging and packaging waste

EN13428: 2004 Packaging - Requirements specific to manufacturing and composition - Prevention by source reduction

EN13429: 2004 Packaging - Reuse

EN13430: 2004 Packaging - Requirements for packaging recoverable by material recycling

EN13431: 2004 Packaging - Requirements for packaging recoverable in the form of energy recovery, including specification of minimum calorific value

EN13432: 2004 Packaging - Requirements for packaging recoverable through composting and biodegradation - test scheme and evaluation for the final acceptance of packaging

<sup>29</sup> As long as these are agreed with the appropriate enforcing authority

<sup>30</sup> The smallest part of packaging considered in the standard is a component. Usually a number of components will be brought together to form a functional unit of packaging and these may in turn be brought together in a complete packaging system which could comprise primary, secondary and tertiary packaging.

Requirements was published. This does not appear to have happened as yet, despite the standards gaining their "harmonised status" in 2005 and the Commission report being released in December 2006. It is clear however, that unless the workability of the standards can be demonstrated both in their use by companies and enforcement by Member States there is likely to be a call for a tightening up of the Essential Requirements in order to make them more prescriptive and leave less freedom for companies to make their own decisions.

## V) Ensure packaging complies with Heavy Metal requirements

The Directive (article 11) requires that Member States (original EU-15) ensure that the sum of concentration levels of lead, cadmium, mercury and hexavalent chromium present in packaging and packaging components shall not exceed the following levels:

- 600ppm by weight two years after 30 June 1996
- 250ppm by weight three years after 30 June 1996
- 100ppm by weight five years after 30 June 1996

with specific exception for packaging made with lead crystal. The Commission also granted an exemption for recycled plastic crates operated within a closed loop.

The date that the 100ppm target level came into force was 1st July 2001 and hence the maximum level for the sum of these four heavy metals in packaging is now 100ppm. Although the newer EU Member States were granted derogation on achieving the lower limit, this has now passed. Hence the 100ppm heavy metal limit now applies in all EU Member States.

Although while not strictly correct, the heavy metal limits are commonly treated as part of the Essential Requirements.

## VI) Reuse of packaging

The Directive states that Member States may encourage environmentally sound reuse system and use of recycled materials. Economic instruments may also be adopted to promote the objectives of the Directive.



## Business Case

Two important types of qualitative commercial benefit can be identified:

### (a) Minimise the Cost of (Legal) Compliance

In Europe, the PPWD mandates that Member States achieve a minimum level of plastic packaging recycling. In general, through adoption of producer responsibility, industry funded recovery organisations have been established to ensure this target is achieved.

Following these guidelines will be a very important contributor in helping to maximise process efficiency and thereby minimise the associated levies charged by recovery organisations to companies to fund the process.

The PPWD also requires that companies design their packaging to be recoverable. For packaging where mechanical recyclability is desirable, adoption of these guidelines at the start of the design phase will ensure unnecessary difficulties are avoided and hence unwanted delays and associated oncosts prevented. In general, the cost of getting it right will be marginal, provided these considerations are built in at the start of the design process. Using the CEN standard on material recovery to demonstrate compliance (recommended method) also requires demonstration that material combinations being used will not adversely interfere with current recycling. These guidelines have been developed specifically as an aid to avoid such issues. Further, administrative costs for compliance will also be minimised if the guidelines are integrated into Environmental Management Systems and New Product Innovation processes.

Outside of Europe, Japan, Taiwan and Korea have introduced legislation on broadly similar principles to the PPWD. In addition many states within the countries of Latin America have adopted selected elements of the PPWD into to their state legislature.

The above commercial benefits would still apply to any country or state where recycling targets for plastics exist through legislation or voluntary agreements. In addition the EU Essential Requirements legislation also applies to packaging imported into the EU and de facto is becoming a global standard for suppliers. The benefits indicated when designing for mechanical recyclability are therefore also globally relevant in this context.

There are also a number of national trends across Europe that seek to reward packaging that conforms to specific design rules and / or penalise those that don't:

A further voluntary agreement on Packaging Sustainability between the Austrian government and industry has been completed and will run for a period of 10 years. The focus is now on supporting investments made in PET bottle to bottle recycling and not on maintaining a supply of refillable drinks containers. From 2008, at least 55% of PET bottles have to be recycled or recovered (up from the previous target of 50%). In addition, minimum tonnage targets have been set for the amount of post-consumer PET to be used in the production of PET bottles annually. This new agreement is also much broader than the Sustainability Agenda for Beverage Containers that it replaces as it includes a commitment to reduce greenhouse gas emissions along the PET supply chain.

In France, the national Green Dot organisation (Eco-Emballages) doubles the recycling fee for new packaging materials or applications if rigid packaging currently recycled is replaced by rigid packaging without a recycling channel<sup>31</sup>. (This provision does not apply to specialist applications where the packaging is not economic to recycle). The recycling fee is reduced by 10% for packaging with over 50% recycled content. The Swedish recovery organisation REPA has removed the concept of the same fee being paid for all packaging of the same material and for plastic packaging has introduced a 10% lower fee for carrier bags, point of sale and produce packaging over other plastics packaging because they are more readily separable.

Similarly in Norway, recovery fees are 88% more for dark blue versus light blue PET bottles or for bottles where the sleeve covers more than 75% of the surface.



Material Reclamation Facility (MRF)

<sup>31</sup> This penalty will be reimbursed in full if a recycling channel is established for the material within two years of the material first being placed on the market.



Finally, in France (COTREP) and Switzerland (PRS), technical committees evaluate the recyclability of plastic packaging (PET bottles only in Switzerland). While these judgements are advisory both in France and Switzerland, a positive evaluation will facilitate the marketing of the product.

## (b) Satisfy Societal Expectation

Societal pressure continues to build for companies to become more sustainable and therefore lower their resource use and environmental impact. Adoption of eco-design principles will help reduce the risk of further regulatory intervention impacting on the products being produced. Enabling the sustainable recovery of packaging waste is seen as an important contributor towards maximising resource efficiency and minimising environmental impact. Although recovery includes a variety of legitimate and legally allowed processes (e.g. mechanical recycling, energy recovery, composting, etc.), at present society still places a high priority on mechanical recycling over the others; in the case of bottles and a range of commonly recycled plastic items this is likely to remain the position for some time in the future.



## Recycle on the go

Importantly retailers are responding to consumer concerns in this area and are setting their own sustainability programs. As a consequence, product manufacturers and packaging suppliers up the supply chain are having to respond to the resultant demands set by the major retailers if their products are to be favoured and business retained. A relevant example in the current context is the Walmart scorecard introduced in the USA. This scorecard covers nine different metrics, two of which are recyclability and recycled content. Thus the higher the recyclability of the packaging and the more recycled content it contains the higher and hence potentially more favourable the overall score will be.



While Walmart indicates that the scorecard should be used as a business management tool and not an environmental indicator, this latter possibility will always remain.

For this reason, companies who ignore environmental considerations within their design process are likely to come under increasing pressure to take corrective action, particularly if the packaging has a negative impact on an existing legitimate recycling stream.



## Density Range of Plastics Commonly used in Packaging

Table 8 below shows the density ranges of plastics commonly used to make plastic packaging and components.

Table 8: Polymer densities and behaviour during sink / float tank separation

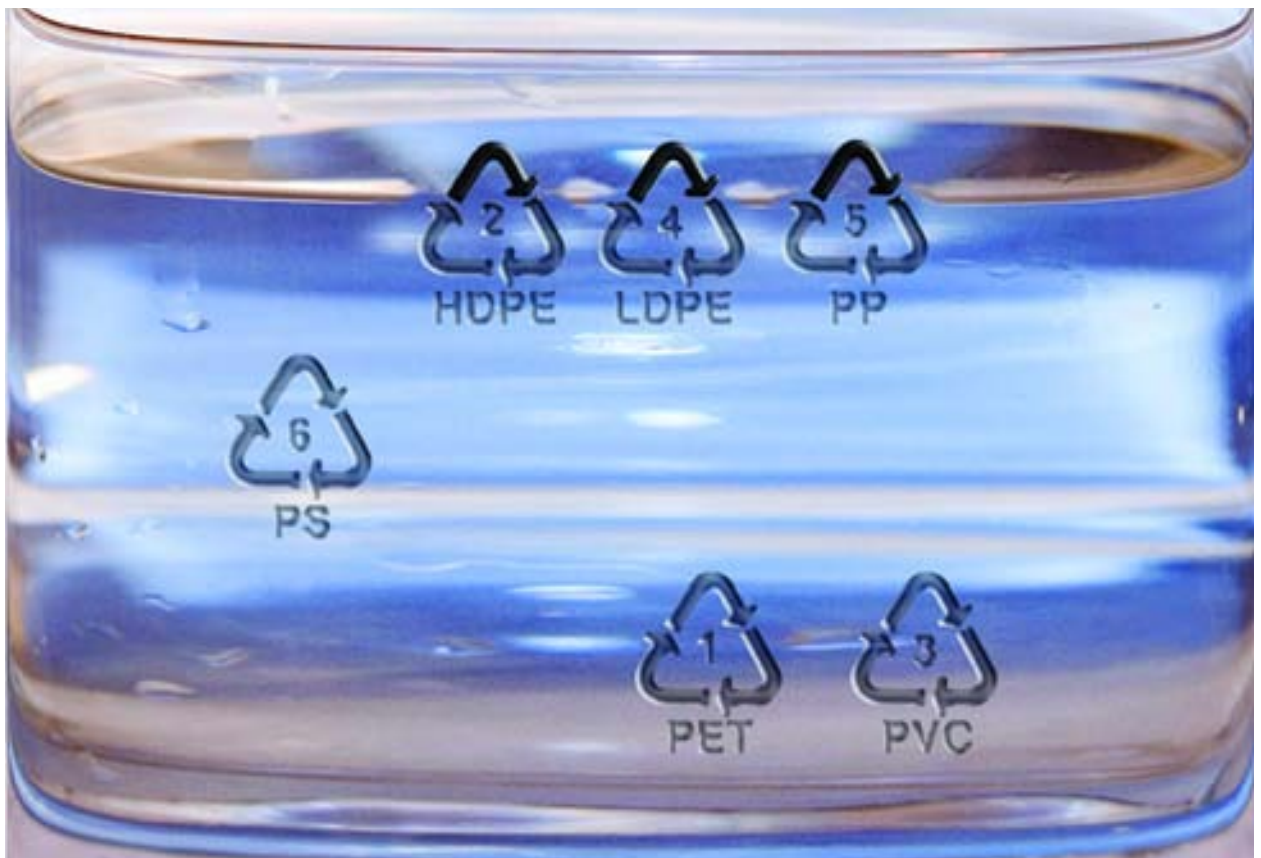
Polymer	Density g/cm <sup>3</sup>	Behaviour in Float Process*
Ethylene vinyl acetate (EVA)	Less dense than water	float
Polypropylene (PP)	0.90 – 0.92	
Low density polyethylene (LDPE)	0.91 – 0.93	
High density polyethylene (HDPE)	0.94 – 0.96	
Polystyrene (PS)	1.03 – 1.06	variable
Nylon (PA)	1.13 – 1.14	sink
Acrylic (PMMA)	1.17 – 1.20	
Polycarbonate (PC)	1.20	
Polyethylene terephthalate (PET)	1.30-1.38	
Polyvinyl chloride (PVC)	1.32-1.45	

Densities are approximate and relate to virgin unpigmented and unfilled polymer. Colouring with 4% pigment can raise density by 0.03 g/cm<sup>3</sup> which may cause further overlaps of polymer densities.

Hydro cyclones can be fine-tuned to separate plastic materials provided their densities differ by ca  $\geq 0.05$  g/cm<sup>3</sup>.

**Note:**

The densities of flake derived from PP and HDPE packaging overlap and are difficult to separate. The density difference between PS and HDPE whilst sufficient to permit separation in a hydro cyclone, is not sufficiently large from water to ensure that is fully separable with either the light or heavy fractions and thus can cause recycling issues with for example PET.



\* A density difference between the polymer and water of ca  $\geq 0.05$  gcm<sup>3</sup> is required to ensure that the material will either sink or float in a sink / float tank

## Key Organisations to contact for further information

### APR

#### The Association of Postconsumer Plastic Recyclers

Address: 1001 G Street NW, Suite 500  
 Washington, DC 20001  
 Tel: +1 202 316 3046  
 e-mail: [info@plasticsrecycling.org](mailto:info@plasticsrecycling.org)  
 Web site: [http://www.plasticsrecycling.org/contact\\_us/index.asp](http://www.plasticsrecycling.org/contact_us/index.asp)

### EPBP

#### European PET Bottle Platform (EPBP)

e-mail: [epbp@epro-plasticsrecycling.org](mailto:epbp@epro-plasticsrecycling.org)  
 website: [www.e-pro-plasticsrecycling.org/PETbottleplatform/](http://www.e-pro-plasticsrecycling.org/PETbottleplatform/)

### EPRO

#### European Association of Plastic Recycling and Recovery Organisations

Address: Rue de Commerce 31/Handelsstraat 31  
 B-1000 Brussels  
 Tel: + 32 (0) 2 456 84 49  
 Fax: + 32 (0) 2 456 83 39  
 e-mail: [epro@epro-plasticsrecycling.org](mailto:epro@epro-plasticsrecycling.org)  
 website: <http://www.e-pro-plasticsrecycling.org>

### EuPC

#### European Plastics Converters

Address: Avenue de Cortenbergh, 66 P.O. Box 4  
 1000 Brussels - Belgium  
 Tel.: +32 2 732 41 24  
 Fax: +32 2 732 42 18  
 e-mail: [info@eupc.org](mailto:info@eupc.org)  
 website: [www.plasticsconverters.eu](http://www.plasticsconverters.eu)

### EuPR

#### European Plastics Recyclers

Address: Avenue de Cortenbergh 66  
 B-1000 Brussels  
 Belgium  
 Tel: +32 2 742 96 82  
 Fax: +32 2 732 63 12  
 e-mail: [info@plasticsrecyclers.eu](mailto:info@plasticsrecyclers.eu)  
 website: [www.plasticsrecyclers.eu](http://www.plasticsrecyclers.eu)

### NAPCOR

#### National Association for PET Container Resources

Address: PO Box 1327  
 Sonoma, CA 95476  
 Tel: +1 707-996-4207  
 e-mail: [information@napcor.com](mailto:information@napcor.com)



## Material identification

Article 8.2 of Directive 94/62/EC requires that “to facilitate collection, reuse and recovery including recycling, packaging shall indicate for purposes of its identification and classification by the industry concerned the nature of the packaging material(s) used” and that “the European Commission determine the numbering and abbreviations on which the identification system is based and shall specify which materials shall be subject to the identification system”.

The European Commission published its Decision on Material Identification in January 1997 (97/129/EC). The system proposed is a detailed one, based on numbers and abbreviations, and covers an extensive range of material types including paper, plastics, steel, aluminium and individual composite materials. The Commission system has not been used previously and its use remains voluntary.


**Table 9: Extract from Commission Decision 97/129/EC Identification System for Packaging Materials**

Numbering and Abbreviation System for Plastics	Abbreviations	Numbering
Polyethylene terephthalate	PET	1
High density polyethylene	HDPE	2
Polyvinyl chloride	PVC	3
Low density polyethylene	LDPE	4
Polypropylene	PP	5
Polystyrene	PS	6

Additional reference numbers remain undefined.

The Commission’s material identification system for plastics is very similar to the existing and well-established SPI material identification code already developed by the plastics material sector. The SPI system uses a triangle made of chasing arrows<sup>32</sup> with the number of the polymer placed inside and the polymer abbreviation placed outside the base. The numbers and abbreviations used for the plastics are indicated below together with the use of the SPI system for PET as an example. In this system, all other plastics are allocated the number ‘7’. In addition, the abbreviations for PVC and PET are slightly different to those in the Commission decision.

**Table10: SPI material identification system**

	Abbreviations	Numbering	
Polyethylene terephthalate	PET	1	
High density polyethylene	HDPE	2	
Polyvinyl chloride	PVC	3	
Low density polyethylene	LDPE	4	
Polypropylene	PP	5	
Polystyrene	PS	6	
	OTHER	7	

The material identifier used should be shown clearly and ideally moulded into the container / component or in the case of films, lightly and repeatedly printed across the material. On containers, the marking should be clearly distinct from any other letter or cavity reference number to avoid confusion. For consistency, material identifiers should generally be embossed on the base of a container. Exceptionally, the identifier can be located on an alternative position close to the base (e.g. to avoid the risk of cracking due to bottle design) or the identifier (for the predominant material) printed on the label. (Printing the material identifier on a label whilst convenient, potentially leads to confusion as it could refer to the label material, the container plastic or the full container, including lid).

Further information can be obtained from the Plastics Europe<sup>33</sup> and American Plastics Council<sup>34</sup> web sites.

<sup>32</sup> Whilst the symbol resembles the ‘recycling triangle’ or mobius loop it is used merely as an identifier for the predominant plastic type and does not necessarily imply that the material is recyclable.

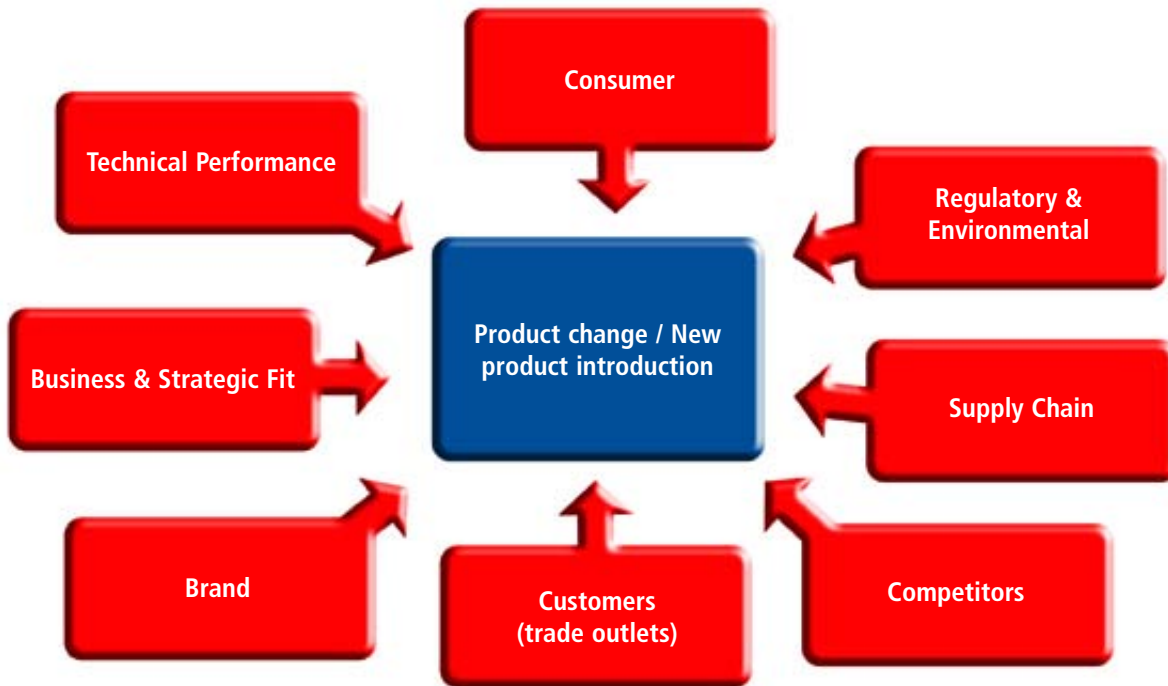
<sup>33</sup> <http://www.plasticseurope.org/Content/Default.asp?> Enter polymer identification in “Search”, enter and then scroll down results to obtain the following document: Polymer Identification Symbols For Packaging

<sup>34</sup> [http://www.americanchemistry.com/s\\_plastics/bin.asp?CID=1102&DID=4645&DOC=FILE.PDF](http://www.americanchemistry.com/s_plastics/bin.asp?CID=1102&DID=4645&DOC=FILE.PDF) for Resin identification codes fact sheet.

## Integration of environmental aspects into the packaging design process

The design of a packaging system is a complex process which frequently lies on the critical path of any network for product change / new product introduction. A wide range of inputs has to be taken into account. The key ones are conveniently summarised in the diagram below:

Figure 3: Typical range of considerations taken into account during the design of packaging<sup>35</sup>



If environmental and regulatory assessments are included with the wide range of inputs that have to be taken into account at the start of a project they can become part of the product opportunity rather than an issue at the end. Such issues are invariably more difficult to resolve and can lead to significant on-costs and serious time delays. Their relative importance will of course vary depending on the goals and positioning of the business and the brand.

It is recommended that companies adopt a new product innovation process that automatically includes an environmental assessment<sup>36</sup>. Ideally, this environmental assessment becomes part of a recognised environmental management system (e.g. ISO 14001). The European CEN standards (see Appendix 4) provide an excellent management approach for carrying out this environmental assessment<sup>37</sup>. Following these standards should ensure that companies automatically address the key environmental aspects that need to be addressed for packaging. Use of the present document by packaging designers / specifiers should help ensure that the key criteria covered in these standards concerning plastic packaging has been satisfied.



<sup>35</sup> Derived from Viadynamics' Solution Space® [www.viadynamics.com](http://www.viadynamics.com)

<sup>36</sup> See for example ISO/TR 14062:2002 Title: Environmental management - Integrating environmental aspects into product design and development.

<sup>37</sup> EUROOPEN have published a guidelines document to the use of these standards by companies. Non EUROOPEN members can purchase the guide. See <http://www.europen.be/index.php?action=onderdeel&onderdeel=6&titel=Publications> - 01/10/05 Essential Requirements for Packaging in Europe: A Practical Guide to Using the CEN Standards

# Case Study

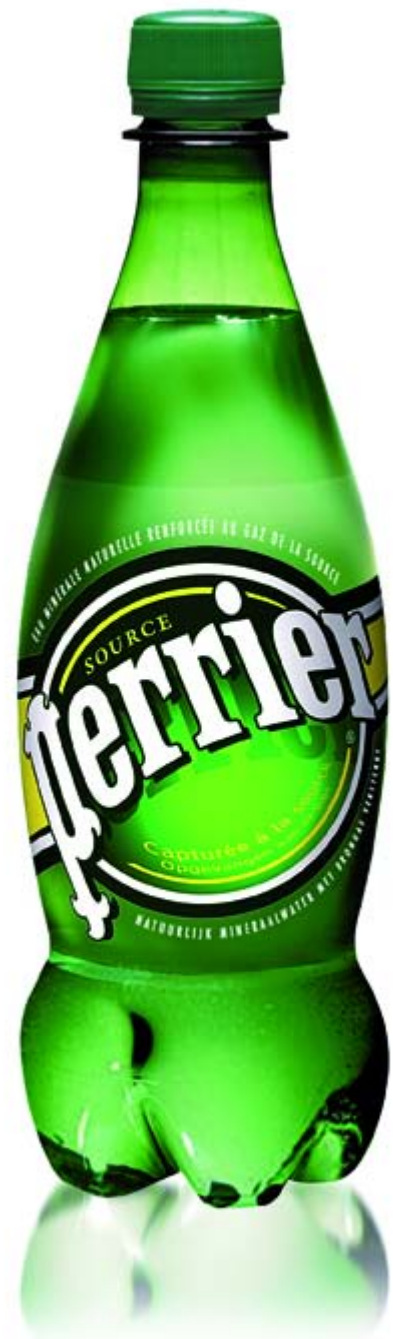
A good example of integrating environmental aspects into the design process can be seen in the following case study:

Nestlé is committed to reducing the environmental impact of packaging, without jeopardising the safety, quality or consumer acceptance of its products. Nestlé Waters France (NWF), the French operating companies of the Nestlé bottled water business, carefully considers the environmental impact of its developments and in cases of its packaging, consults with COTREP when needed for all new packaging or major modification. The company recognises that eco-design is important to make sure that plastic bottles put on the market are compatible with existing recycling streams. Both the R&D and Marketing departments of NWF support the availability of the guide on plastic material compatibilities produced by COTREP in France. NWF has developed with COTREP an eco-conception tool for the new packaging in order to take in account all the environmental aspects.

Concerns about the recyclability of their packaging have resulted in design optimisation: In 2001, Nestlé Waters France had been investigating the option of introducing a new PET Perrier bottle with an aluminium cap. Following discussions with COTREP about possible recycling issues, this option was abandoned and, finally, the cap was made of HDPE. COTREP advice was also sought for the introduction of the Fluo bottle in 2002.

Nestlé Waters France very much appreciates the ability to optimise the design through the use of guidelines and discussions with COTREP as soon as the first prototypes are agreed by marketing. More recent evidence of the benefits of this process is seen with Vitalitos and Contrex fines bulles: the bottles are in PET, the sleeves are in PP and are glued to the bottle at a single point and the cap is in HDPE, thereby maximising the ease

and value of recycling the PET. Another major benefit of this process is the rapid confirmation by COTREP that the packaging is recyclable. This documentation is then used to form one important part of the Essential Requirements technical dossier.



## Glossary of terms

<b>APR</b>	The Association of Post Consumer Plastic Recyclers
<b>CEN</b>	The European Committee for Standardization
<b>CEPE</b>	The European Council of Paint, Printing Ink and Artists' Colour Industry
<b>COTREP</b>	Comité Technique de Recyclage des Emballages Plastiques
<b>EPS</b>	Expanded polystyrene
<b>EuPC</b>	European Plastics Converters
<b>EuPIA</b>	The printing ink group within the European Council of Paint, Printing Ink and Artists' Colour Industry
<b>EuPR</b>	European Plastics Recyclers
<b>EUROPEN</b>	The European Organisation for Packaging and the Environment
<b>EVA</b>	Ethylene vinyl acetate
<b>EVOH</b>	Ethylene vinyl alcohol
<b>FTIR</b>	Fourier Transform Infrared Spectroscopy
<b>HDPE</b>	High density polyethylene
<b>HCl</b>	Hydrochloric acid
<b>HIPS</b>	High-impact polystyrene
<b>IPP</b>	Integrated Product Policy
<b>IR</b>	Infrared (radiation)
<b>ISO</b>	International Standards Organisation
<b>LDPE</b>	Low density polyethylene
<b>LLDPE</b>	Linear low density polyethylene
<b>MDPE</b>	Medium density polyethylene
<b>MRF</b>	Materials reclamation facility
<b>NAPCOR</b>	National Association for PET container resources
<b>NIR</b>	Near Infrared (radiation)
<b>OPET</b>	Oriented PET
<b>OPP</b>	Oriented polypropylene
<b>OPS</b>	Oriented polystyrene
<b>PA</b>	Polyamide (nylon)
<b>PBT</b>	Polybutylene terephthalate
<b>PC</b>	Polycarbonate
<b>PEN</b>	Poly (ethylene 2,6 naphthalate)
<b>PET</b>	Polyethylene terephthalate
<b>PETG</b>	Polyethylene terephthalate glycol
<b>PLA</b>	Polylactic acid
<b>PMMA</b>	Polymethyl methacrylate
<b>PP</b>	Polypropylene
<b>PPWD</b>	The European Packaging and Packaging Waste Directive
<b>PRS</b>	PET-Recycling Schweiz
<b>PS</b>	Polystyrene
<b>PU</b>	Polyurethane
<b>PVDC</b>	Polyvinyl ethylene dichloride
<b>PVC</b>	Polyvinyl chloride
<b>REPA</b>	Service organisation for all Recovery Organisations in Sweden (except glass)
<b>SPI</b>	Society of Plastics Industry
<b>6EAP</b>	European Union Sixth Environmental Action Program



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- Prevention by source reduction



The guidelines have been supported by the organisations listed below. These Organisations encourage the concept of appropriate design for recyclability in the broader context of designing for minimum environmental impact of the packaging system. As such they encourage designers and specifiers of plastic packaging to build the considerations identified in this document into their packaging design process.

## The European PET bottle Platform

### ABC

Alliance for plastic Beverage Containers sustainability

Address: Boulevard Louis Schmidt 119 - box 2  
B-1040 Brussels  
Belgium

Tel: +32 2 559 26 67  
Fax: +32 2 559 22 96  
e-mail: cvandongen@eur.ko.com

### EPRO

European Association of Plastic Recycling & Recovery Organisations

Address: Rue du Commerce 31  
B-1000 Brussels  
Belgium

Tel: +32 2 238 97 81  
Fax: +32 2 238 99 98  
e-mail: epro@epro-plasticsrecycling.org  
website: <http://www.epro-plasticsrecycling.org>

### EuPR

European Plastics Recyclers

Address: Avenue de Cortenberg 66  
B-1000 Brussels  
Belgium

Tel: +32 2 742 96 82  
Fax: +32 2 732 63 12  
e-mail: [info@plasticsrecyclers.eu](mailto:info@plasticsrecyclers.eu)  
website: [www.plasticsrecyclers.eu](http://www.plasticsrecyclers.eu)

### Petcore

PET Containers Recycling Europe

Address: Ave E van Nieuwenhuysse 4  
1160 Brussels  
Belgium

Fax: +32 2 675 39 35  
e-mail: [petcore@btconnect.com](mailto:petcore@btconnect.com)  
website: [www.petcore.org](http://www.petcore.org)

[www.epro-plasticsrecycling.org/PETbottleplatform/](http://www.epro-plasticsrecycling.org/PETbottleplatform/)

### APR

Association of Postconsumer Plastic Recyclers

Address: 1001 G Street NW, Suite 500  
Washington, DC 20001

Tel: +1 202 316 3046  
e-mail: [info@plasticsrecycling.org](mailto:info@plasticsrecycling.org)  
Web site: [www.plasticsrecycling.org](http://www.plasticsrecycling.org)

APR endorses the spirit and intent of the "Recyclability by Design" and encourages the concept of appropriate design for recyclability to enhance every recycling opportunity. While regional differences may exist, this is an important and valuable tool to assist packaging designers in making choices that aid plastic container recycling.

### BSDA

British Soft Drinks Association

Address: 20-22 Stukeley Street,  
London WC2B 5LR.

Tel: +44 (0) 20 7430 0356  
Fax: +44 (0) 20 7831 6014  
e-mail: [bsda@britishsoftdrinks.com](mailto:bsda@britishsoftdrinks.com)  
website: [www.britishsoftdrinks.com](http://www.britishsoftdrinks.com)



### EPRO

European Association of Plastics Recycling and Recovery Organisations

Address: Rue de Commerce  
31/Handelstraat 31  
B-1000 BRUXELLES / B-1000 BRUSSEL

Tel: +32 (0) 2 456 84 49  
Fax: +32 (0) 2 456 83 39  
e-mail: [epro@epro-plasticsrecycling.org](mailto:epro@epro-plasticsrecycling.org)  
website: [www.epro-plasticsrecycling.org](http://www.epro-plasticsrecycling.org)



### EuPC

European Plastics Converters

Address: Avenue de Cortenberg, 66  
P.O. Box 4  
1000 Brussels - Belgium

Tel: +32 2 732 41 24  
Fax: +32 2 732 42 18  
e-mail: [info@eupc.org](mailto:info@eupc.org)  
website: [www.plasticsconverters.eu](http://www.plasticsconverters.eu)



### EuPR

European Plastic Recyclers

Address: Avenue de Cortenberg 66,  
P.O. Box 4  
1000 Brussels, Belgium

Tel: +32 2 742 96 82  
Fax: +32 2 732 63 12  
e-mail: [info@plasticsrecyclers.eu](mailto:info@plasticsrecyclers.eu)  
website: [www.plasticsrecyclers.eu](http://www.plasticsrecyclers.eu)



### Recoup

RECYCLING OF USED Plastics Limited

Address: 1 Metro Centre, Welbeck Way, Woodston,  
Peterborough PE2 7UH (UK)

Tel: +44 (0) 1733 390021  
Fax: +44 (0) 1733 390031  
e-mail: [enquiry@recoup.org](mailto:enquiry@recoup.org)  
website: [www.recoup.org](http://www.recoup.org)



## COTREP

### Chambre Syndicale des Emballages en Matière Plastique

Address: 5, rue de Chazelles  
75017 Paris

Tel: +33 (0)1 46 22 33 66  
Fax: +33 (0)1 46 22 02 35  
e-mail: [infos@packplast.org](mailto:infos@packplast.org)  
website: [www.packplast.org](http://www.packplast.org)

### Eco Emballages

Address: 44 avenue Georges  
Pompidou  
92300 Levallois-Perret

Tel: +33 (0)1 40 89 99 99  
Fax: +33 (0)1 40 89 99 88  
e-mail: [infos@packplast.org](mailto:infos@packplast.org)  
website: [www.ecoemballages.fr](http://www.ecoemballages.fr)

### Valorplast

Address: 14 rue de la République  
92800 Puteaux

Tel: +33 (0)1 46 53 10 95  
Fax: +33 (0)1 46 53 10 90  
e-mail: [infos@packplast.org](mailto:infos@packplast.org)  
website: [www.valorplast.com](http://www.valorplast.com)

[www.cotrep.fr](http://www.cotrep.fr)

Plastic material combinations additional to those suggested in these guidelines, although not generally applicable, may be possible in a specific country. Some of these organisations may be able to provide additional technical details relating to recyclability considerations for specific materials in specific countries.



# Plastics Packaging **Recyclability by Design**

Recoup, 1 Metro Centre, Welbeck Way, Woodston,  
Peterborough PE2 7UH (UK)  
Tel: + 44 (0) 1733 390021 Fax: + 44 (0) 1733 390031  
Email: [design@recoup.org](mailto:design@recoup.org) [www.recoup.org](http://www.recoup.org)

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