Note to the Reader

This guide has been prepared by the Association of Postconsumer Plastic Recyclers as a service to the plastic packaging industry to promote the most efficient use of the nation’s plastics recycling infrastructure and to enhance the quality and quantity of recycled postconsumer plastics. The information contained herein reflects the input of APR members from a diverse cross-section of the plastics recycling industry, including professionals experienced in the recycling of all postconsumer plastic bottles discussed in this guideline. It offers a valuable overview of how package design impacts conventional plastics recycling systems and provides useful recommendations on how problems routinely encountered by plastics recyclers might be addressed through design changes that make plastic bottles more compatible with current recycling systems. Because new technological developments are always being made, this guide cannot anticipate how these new developments might impact plastic bottle recycling. Thus, while the information in this guide is offered in good faith by APR as an accurate and reliable discussion of the current challenges faced by the plastics recycling industry, it is offered without warranty of any kind, either expressed or implied, including WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, which are expressly disclaimed. APR and its members accept no responsibility for any harm or damages arising from the use of or reliance upon this information by any party. APR intends to update this document periodically to reflect new developments and practices.

About APR...

The Association of Postconsumer Plastic Recyclers is the North American trade association representing companies that acquire, reprocess and sell the output of more than 90% of the postconsumer plastic bottle processing capacity in North America. Its membership includes independent recycling companies of all sizes and the recycling interests of many other companies. APR strongly advocates the recycling of all postconsumer plastic packaging and recommends the use of postconsumer plastics in products, where possible.

APR strives to eliminate obstacles to plastic recycling with technical programs and guidelines. These initiatives have been produced in response to a need to provide information to the plastic packaging industry on what elements of package design may or may not affect the recycling of that package in current systems.
ELEMENT ONE
Design for Recyclability Guidelines for Plastic Bottle Recycling

This document is prepared to assist plastic bottle designers and fabricators in constructing bottles for specific product applications that are compatible with the broadest range of recycling operations and to enhance the quality and quantity of postconsumer plastic packaging materials. It offers a valuable overview of the challenges routinely encountered by plastic recyclers and useful recommendations on how these problems might be addressed through changes in packaging design. Designing to enhance recyclability should be in the forefront of package design considerations. This document, first written in 1994 was updated in 1998, 2005, 2008, 2009, 2011, and again in 2012.

“Criteria to Consider when Evaluating the Recyclability of a PET or HDPE Bottle Variant”

The objective of this document is to outline criteria to consider if a variant of the PET or HDPE bottle is being evaluated for recyclability in existing PET and HDPE reclaiming systems. This document will aid PET and HDPE stakeholders in evaluating the compatibility of a plastic bottle packaging innovation with existing recycling systems and products, with the end result of maintaining the viability of the recycled PET and HDPE bottle stream. APR has developed “Critical Guidance Documents” for HDPE and PET that provide a short list of laboratory testing to be done and evaluation criteria to help innovators understand the impacts of their innovations on plastic bottle recycling.

APR also has prepared lists of "Critical Issues" for specific innovations frequently made to plastic bottles.

ELEMENT TWO
Design for Recyclability Testing Protocols

The overriding philosophy is to produce protocols that provide accurate indications of a product’s compatibility with the PET or HDPE bottle recycling process while maintaining a degree of simplicity in order to be useful to the majority of laboratories.

Flake Contamination Tests for PET and HDPE Bottles

These protocols allow label and/or adhesive manufacturers to evaluate the impact of a product during a typical recycling process.

Bleeding Label Tests for PET and HDPE Bottles

These protocols test for effects of water-based inks on the recycling process and product.

PET Test of Barrier Material Residue

This test allows for the quantification of various epoxy, nylon, and EVOH barrier material residues in cleaned PET flake.
**PET Dissolution Quality Test**
This test allows for a qualitative evaluation of recycled PET by dissolving the polymer and comparing resultant residue color.

**ELEMENT THREE**
**“Champions for Change” Cooperative Testing Program**
This program invites consumer product companies, technology companies, suppliers, converters, etc., to become CHAMPIONS by informing APR members formally of planned changes or modifications in a regularly recycled bottle. APR members will then volunteer to provide testing using various recycling processes in order to generate data regarding the packaging’s impact or compatibility with current recycling processes.

“Guidance Documents”
APR has prepared two sets of testing procedures with evaluation guidance to support the “Champions for Change”. The documents are resin specific, meaning one set is for PET and another set is for HDPE. The first document in the set is the Critical Guidance Document, a short list of tests that capture many of the recycling issues specific to the bottle resin type. The document describes the controls to be used, the tests to be run, testing procedures, and evaluation criteria. The second document is the Applications Guidance in which the innovation material is challenged to meet or exceed criteria more specific to particular end uses, such as making new bottles from recycled bottles.

Meeting the APR Critical Guidance may be used as a supplemental demonstration of proper RIC assignment for a given resin.

**ELEMENT FOUR**
**APR Design for Recyclability Award**
The APR has crafted an awards program to promote and publicize packaging improvements designed to be compatible with current plastic recycling processes. Packaging currently in the recycling stream that is modified to offer enhanced recycling compatibility, and completely new packaging designs will be considered for the program. The award will be promoted by APR. Recipient(s) will receive personal recognition of their achievement by APR.

**ELEMENT FIVE**
**Guidance Recognition Program**
This program allows companies to build on work done for the "Champions for Change" program to evaluate new plastic bottle innovations. Innovators should test their innovations per the APR Critical Guidance Document and the Applications Guidance Documents. Innovations that meet or exceed APR’s guidance and are not in conflict with the Design for Recyclability Guidelines can be publicly recognized and may be authorized to use a trademarked logo, “Meets Recycling Guidance”. This is a fee program and requires signed agreements to proceed.
DESIGN FOR RECYCLABILITY GUIDELINES

Purpose
This document has been prepared to assist plastic bottle designers, fabricators, and packaging decision-makers in constructing bottles for a wide range of specific product applications that are also compatible with the broadest range of recycling operations and technologies.

The guiding principle of any packaging design must be “fitness of purpose.” Beyond this, designing to enhance recyclability should be in the forefront of design considerations.

To maximize a bottle’s recycling potential, it is vital to consider the compatibility of the bottle’s construction with current plastic bottle recycling technology. Incorporating “design for recyclability” criteria will increase the potential for well-designed packaging to be reused and remanufactured into new products which have value to the consumer and enhance the economic viability of plastic bottle recycling.

The presentation in this document is restricted to plastic bottle recycling, although many other forms of plastic recycling exist. And, it only addresses the major types of plastic bottle recycling that currently exist, including PET and HDPE with PP and PVC plastic bottles occasionally recycled.

These Guidelines are just one component of the APR’s Design for Recyclability Program, which strives to eliminate barriers in plastic recycling by providing information -- through technical programs, guidelines and testing protocols -- to the plastic packaging industry in order to determine which elements of a new package design may or may not affect the recycling of that package in conventional recycling systems currently in operation. The elements of APR’s Design for Recyclability Program can be seen beginning on Page 2.

Overview of Plastic Bottle Recycling Collection
Most of the plastic bottles collected for recycling today come from curbside collection programs where householders separate designated recyclable materials from their trash and place them out for collection in special receptacles or bags. These recyclables may include containers such as glass and plastic bottles, milk cartons, juice boxes, aluminum cans and foil, and steel cans, as well as newsprint and other recyclable paper products. Some communities allow householders to commingle recyclables, by placing recyclables of different material types into the same receptacle. Others require some level of material segregation, known as source separation. For example, many curbside collection programs require that newsprint and cardboard be bundled, or placed in separate receptacles, and placed alongside receptacles with commingled recyclable containers. These materials are then picked up by the municipality or a contract waste hauler and taken to a materials recovery facility (MRF) for further separation and processing.
Some states and counties have implemented collection systems with even higher levels of source separation. Source separation represents the best opportunity for producing the highest value and highest quality raw materials for recycling since cross-contamination of materials is much less likely. The most common source separation approaches consist of the following:

- Bottle collection in states that have bottle deposit legislation;
- Programs that require the homeowner to set out separate containers for each recyclable material category;
- Programs where commingled recyclables are separated at the truck by collection crews;
- Programs that employ drop-off centers where homeowners are asked to take recyclables to a drop-off location, separate them by material type, and place them into designated receptacles.

Materials are then collected and sent to a MRF, an intermediate processing center, or directly to a specific material processor.
Sorting

Sorting of whole bottles by resin type is essential to effective plastic bottle recycling and generally takes place at the materials recovery facility (MRF), or at an intermediate processing center (IPC), which consolidates and processes source separated materials. Some plastic reclaimers accept mixed plastic bottle types and separate them at their facility; however, for the purpose of this general discussion, the same sorting principles apply, regardless of where the materials are sorted.

Sorting of commingled recyclable materials is, in general, a labor-intensive effort, even where automated systems are used. Keep in mind that MRF’s and IPC’s separate and prepare several materials for reclamation including glass, aluminum, steel, paper, and plastic. This discussion will be confined to the sorting of rigid plastic bottles.

Sorting Methods

Two basic methods are currently used to sort plastic bottles for recycling. Sorting of whole bottles is carried out manually (by visual inspection) or automatically (detection systems that use sensors to analyze one or more properties of the plastic bottles passing by).

Manual Identification: Sorting of whole bottles by visual inspection is done by bottle shape, color, and/or product recognition. 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 of different plastic polymers. These are called ‘look-alike’ bottles. Most plastic bottles manufactured in the United States are stamped on the bottom with a resin identification code (originally known as the SPI code, now ASTM D7611.). However, this numbering system has limited value to sorting personnel, as the volume at which cost-effective sorting must be done precludes looking at the bottom of every bottle passing by.

Automated Identification: Automated sorting (auto-sorting) systems employ one or more detection systems that use sensors to analyze the physical or chemical properties of plastic bottles passing by and separate them into categories: by resin type, color, or both. Auto-sorting was initially developed to separate PVC from a stream of plastic bottles, using x-ray systems that could easily identify the chorine element in the PVC. However, these systems were limited to detecting PVC only. More recently, techniques based on near-infrared analysis can identify and separate plastic bottles of multiple resin types, providing automated, ‘positive’ selection. Techniques based on optical scanning using one or more cameras, can separate plastic bottles by color. Although it has limitations, auto-sorting greatly improves the quality and efficiency of the separation process.

Regardless of the method employed to sort whole plastic bottles, it is in the best interest of the MRF or IPC to create products with the greatest market value. A few MRF’s currently accept all rigid plastic packaging for recycling into mixed resin products like plastic lumber. However, most separate incoming materials to maximize the value of the specific categories of materials collected for recycling.
These *Guidelines* will discuss five plastic bottle categories that presently represent more than 99 percent of the plastic bottles used to package consumer products. Sorting these materials properly offers the best opportunity to maximize their value for recycling into new products.

Automatic sorting can also be done for flake, but only as a “polishing” step to remove low levels of identified materials.

**Reclamation**

Reclamation facilities employ a series of processing stages using a wide range of systems and technologies to prepare plastic bottles for recycling. It would be impractical to describe all of them in detail, therefore, only the most common recycling process stages will be discussed. These stages include Granulation and Air Classification, Washing, Separation, Rinsing/Drying and Melt Filtering.

The two most important factors in all reclamation operations are yield and quality. Any attachment to a plastic bottle, such as closures, closure liners, base cups, inserts, labels, pour spouts, handles, sleeves, safety seals, coatings and layers can impact the recovery rates of the base resin (i.e., the resin the bottle is made from) by reducing yield and increasing recycling costs. These attachments, when not compatible with the base resin being recovered, represent a significant cost to the processor in terms of separation, recovery and waste disposal, and can have an adverse effect on the quality of the PCR (postconsumer resin) produced.

The table below shows typical yields reported by plastic reclaimers for a variety of base resins. This table shows a significant difference in the yield of the base resin due to attachments. Compare for example, two-piece PET soda bottles with a base cup vs. a one-piece PET soda bottle, or a HDPE milk jug vs. a HDPE detergent container.

<table>
<thead>
<tr>
<th>Bottle Type</th>
<th>Base Resin Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-piece PET soda bottles (w/base cup)</td>
<td>65-75 (PET)</td>
</tr>
<tr>
<td>One-piece PET soda bottles &amp; custom PET bottles</td>
<td>75-85 (PET)</td>
</tr>
<tr>
<td>Natural HDPE bottles (e.g., milk, water)</td>
<td>85-95 (HDPE)</td>
</tr>
<tr>
<td>Pigmented HDPE bottles (e.g., soap, detergent)</td>
<td>75-85 (HDPE)</td>
</tr>
<tr>
<td>PVC bottles</td>
<td>85-92 (PVC)</td>
</tr>
<tr>
<td>PP bottles</td>
<td>85-95 (PP)</td>
</tr>
</tbody>
</table>

**Granulation & Air Classification**

Granulation and air classification are generally the first steps in the reclamation process. Following sorting by resin type, whole bottles are ground to a particle size that best suits
the reclamation process. The ground plastic resin is referred to as regrind or flake. Most granulation systems employ an air classifying technique, after size reduction, to separate “light” materials, such as labels, from the heavier base resin being recovered. Granulation loosens plastic and paper labels, and begins to free other attachments that might be on a bottle. Excess glue on labels or attachments has a detrimental impact on granulation and “lights” removal. This increases the cost of reclamation by decreasing the wash cycle yield.

Washing
Washing the ground flake is the next step in most reclamation operations. The washing may be done at ambient or elevated temperatures and could include the addition of detergents or surfactants to aid the cleaning process. Labels, label inks, adhesives, base cups, closures, closure liners, inserts, layers, coatings, or other attachments that may be present in or on the bottle affect washing efficiency and effectiveness. Labels, label inks and label adhesives should all be chosen carefully in order not to cause the base resin to be adversely affected. Labels can contaminate the base resin material; label inks can bleed into the wash water tinting the PCR products; and, label adhesives that can’t be removed can coat the plastic regrind and embed unwanted contaminants. Adhesives used to affix other attachments can be difficult to remove and should be applied sparingly. Washing is often followed by another air classification step to remove lighter materials that have been liberated in the wash system.

Separation
Most conventional reclamation systems use water in sink/float or hydrocyclone systems to separate the base resin from attachments and contaminants based on differences in the density of the different materials used. Plastic resins with densities greater than 1.0 can be separated from resins with densities less than 1.0 (see table below) in water. However, resins with similar or overlapping densities are difficult to separate in these systems. For example, resins with densities greater than 1.0 cannot be easily separated from each other (i.e., PVC from PET). Likewise, resins with densities less than one cannot be separated from each other either (i.e., PP from HDPE). It is therefore important when selecting plastic resins for attachments or components in a bottle design to avoid any such overlap, or to make them from the base resin in the same color as the bottle.
Rinsing/Drying
Rinsing is done to remove residual dirt and detergent from plastic regrind after it is washed and separated. The material is then dried to a level necessary for remanufacturing applications or for further processing stages.

Melt Filtering
An additional processing stage that may take place at a reclaimer, but is generally done at a converter, is called melt filtering. Melt filtering removes non-melting, particulate contaminants in plastic regrind that may remain after sorting, washing and separation stages. Melt filtration occurs inside an extruder, where the plastic regrind is melted and filtered through one or more screens as it is passed through the extruder to make pellets. Converting plastic regrind to pellets provides for a more uniform feedstock for remanufacturing applications and lowers transportation costs for the reclaimer or converter.

End Markets
Recovered materials are used in a wide variety of end-product applications. When a material is recycled back into the same product it is referred to as a product-to-product, or ‘closed loop’ recycling application (e.g., remanufacturing new plastic bottles from old plastic bottles). When product-to-product applications are not possible, the resin recovered from recycled plastic bottles is made into a different kind of product (e.g., remanufacturing PET soda bottles into carpet fiber). When reclaimed plastic bottles are remanufactured into products other than new bottles, it is referred to as ‘open loop’ recycling. Higher value recycling applications require higher quality PCR with excellent performance characteristics. Plastic reclaimers strive to produce the highest quality PCR to access the highest value recycling applications.

### Density Range of Key Plastics and Closure Materials

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>DENSITY (g/cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP</td>
<td>0.90 - 0.92</td>
</tr>
<tr>
<td>LDPE</td>
<td>0.91 - 0.93</td>
</tr>
<tr>
<td>HDPE</td>
<td>0.94 - 0.96</td>
</tr>
<tr>
<td>PET</td>
<td>1.35 - 1.38</td>
</tr>
<tr>
<td>PLA</td>
<td>1.24 - 1.27</td>
</tr>
<tr>
<td>PVC</td>
<td>1.32 - 1.42</td>
</tr>
<tr>
<td>PS</td>
<td>1.03 - 1.06</td>
</tr>
<tr>
<td>Aluminum</td>
<td>~2.10</td>
</tr>
</tbody>
</table>
The Association of Postconsumer Plastic Recyclers supports PCR utilization in the widest range of recycling applications possible to ensure the economic viability of plastic recycling. Better bottle design that incorporates design for recyclability criteria will help improve opportunities for economically viable recycling by reducing the processing costs associated with removing incompatible contaminants and improving the quality of the PCR. The following pages were developed as design guidelines for the specific bottle resin types described.

**RECYCLABILITY**

APR recognizes that the definition of recyclability as limited to just availability for collection is a necessary, but insufficient definition. APR’s experience is that recyclability has at least two components: economic feasibility and technical capability. APR offers the following as elements to be confirmed to claim recyclability in accordance with the technical recommendations provided in these Guidelines:

Economic feasibility –
1. A critical mass of recognizable, unique, and valuable items are available to recycle.
2. Items to be recycled may be collected, sorted, and processed in an economically successful manner.
3. Presence of items up to and including 50 weight percent with existing postconsumer recycled items, all with the same resin identification code, does not reduce the value of the products of an existing recycling process for items with the common resin identification code.

Technically compatibility -
1. An item, such as a package, conforms to the APR Design for Recyclability Guidelines.
2. An item meets the applicable APR Critical Guidance, when such is available.
3. An item meets the applicable APR Applications Guidance, when such is available.

APR recognizes that not all items currently being processed meet these definitions. It is recommended that such items, even of long standing, be reviewed for economic feasibility and technical compatibility with the postconsumer recycling of similar-appearing, and fully recyclable, items.
Description of Terms

APC - American Plastics Council, now American Chemistry Council, Plastics Division

APR - Association of Postconsumer Plastic Recyclers

ASTM – Previously, American Society for Testing and Materials, an international standards organization

EVA - Ethylene vinyl acetate

EVOH - Ethylene vinyl alcohol

HDPE – High density polyethylene

LDPE - Low density polyethylene

LLDPE - Linear low density polyethylene

MDPE - Medium density polyethylene

MRF - Materials recovery facility

NAPCOR - National Association for PET Container Resources

OPP - Oriented polypropylene

PCR - Postconsumer resin

PET - Polyethylene terephthalate

PLA – Polylactic acid

PP - Polypropylene

PS - Polystyrene

PVC - Polyvinyl chloride

SPI - Society of the Plastics Industry
PET Bottles (Carbonated Beverage, Water, and Custom Bottles)

The basic design for recycling guideline to consider when making material choices for any attachment to the bottle is to consider its general compatibility with the base resin (PET) or the removal efficiency in conventional water-based separation systems that separate plastics by density. Attachments may include closures, closure liners, base cups, inserts, labels, pour spouts, handles, sleeves, safety seals, coatings, and layers. PET has a density or specific gravity greater than 1.0 (the density of water) and will sink in these separation systems. For efficient separation and removal in conventional sink/float separation systems, attachments should be made from materials with a density less than 1.0 or be otherwise compatible with PET in the reclamation process. Non-adhering materials with a density less than 1.0 will float in these systems and can be separated easily from the PET. (The density range of key plastic materials can be found on page 8).

COLOR Traditionally, unpigmented PET has the highest value and the widest variety of end-use applications. Transparent, green tinted bottles have the next highest value. Transparent light blue bottles are often included with green or clear streams successfully. PET bottles with other transparent tinted colors may have limited recycling value and may be considered contaminants by many PET reclaimers. Transparent colors other than green may be undesirable. There are some reclaimers, which are able to tolerate transparent, amber, tinted bottles in their systems.

The use of translucent and opaque colors is problematic for many recycled PET end uses because of contamination. In particular, TiO₂ is very detrimental to PET recycling for bottle-to-bottle and engineered resin uses. Although newer sorting technology is capable of identifying white PET from other PET colors, much current sortation capability does not always identify and isolate white opaque PET. Non-TiO₂ opaque and translucent PET bottles are also problematic and should be examined for their impact on the recycling process.

Inclusion of nucleating agents, hazing agents, fluorescers, and other additives for visual and technical effects should be examined specifically by the reclaiming industry for impact on the overall plastic bottle recycling stream. (APR strongly encourages bottle decision makers to test their opaque, translucent, and unusual transparent colors through its Champions for Change cooperative testing program to determine if the selections of color will act detrimentally on the reclaiming industry and if markets may be available for them.)

PVC ATTACHMENTS The use of PVC attachments of any kind on PET bottles is undesirable and should be scrupulously avoided. These attachments generally include, but are not limited to closures, closure liners, labels, sleeves, and safety seals. Very small amounts of PVC (in the parts-per-million range) can severely contaminate and render large amounts of PET useless for most recycling applications. In addition, PVC is very difficult to separate from PET in conventional water-based density separation systems,
due to similar densities (densities greater than 1.0) that cause both to sink in these systems.

**CLOSURES/CLOSURE LINERS** Plastic closures made from polypropylene are preferred to all others, as they are most easily separated from the bottle in conventional separation systems and create an ancillary stream of recyclable material. Closure systems that contain no liners and leave no residual rings, or other attachments, on the bottle after the closure is removed are also preferred. The use of PVC for closures or closure liners is undesirable and should be scrupulously avoided. While the use of EVA closure liners in plastic closures is acceptable to many reclaimers, EVA liners can cause contamination problems when used in aluminum closures. Although tolerated by many reclaimers, the use of aluminum closures should be avoided, as they are more difficult to separate from PET bottles compared to the preferred closure systems (PP, HDPE, LDPE) and add both capital and operating costs to conventional reclamation systems. Closures made from PS or thermoset plastics are undesirable and should be avoided. Closures made from steel are undesirable and should be avoided. Silicone polymer closure parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.

**SLEEVES & SAFETY SEALS** If tamper resistance is required in specific product applications, it should be an integral design feature of the bottle. The use of tamper-resistant or tamper-evident sleeves or seals is discouraged as they can act as contaminants if they do not completely detach from the bottle, or are not easily removed in conventional separation systems. If sleeves or safety seals are used, they should be designed to completely detach from the bottle, leaving no remains on the bottle. The use of PVC sleeves or safety seals is undesirable and should be scrupulously avoided. Foil safety seals that leave foil or remnants or attaching adhesive on the PET bottle should be avoided.

**LABELS** PP, OPP, PE, or other label materials that float in water are preferred to all other label materials. Shrink labels with perforations to facilitate separation from bottles are the preferred label system. Label materials should not delaminate in the reclaimer’s wash system. Paper labels are undesirable and should be avoided as they increase contamination in the PET due to fiber and adhesive carry-over through the reclamation process. Similarly, metallized labels increase contamination and separation costs and should be avoided. In general, the use of plastic labels with a specific gravity of less than 1.0 are preferred for easy removal in conventional water-based density separation systems. Label systems that sink in water because of the choices of substrate, inks, decoration, coatings, and top layer should be avoided. While PS labels are tolerated by many PET reclaimers, PS has been identified as causing serious processing and end-use problems by others, and should only be used if it can be easily and completely removed from the PET in conventional separation systems, such as expanded PS foam, where the PS density is much less than 1.0 gm/cm³ and can be easily separated from PET. The use of PVC labels is undesirable and should be scrupulously avoided. Full bottle sleeves should be so designed that automatic sorting equipment can properly identify the resin used to make the bottle.

**INKS & ADHESIVES** Some label inks bleed color when agitated in hot water and can
discolor PET regrind in the reclamation process, diminishing or eliminating its value for recycling. The APR and NAPCOR have developed a testing protocol to assist label manufacturers in evaluating whether a label ink will bleed in conventional PET reclaiming systems. Label inks must be chosen that do not bleed color when tested under this protocol. The use of label inks that bleed should be scrupulously avoided. Pressure sensitive labels should separate from PET regrind in the hot caustic water wash step. Label adhesives should be water soluble or dispersible at temperatures between 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PET regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. (The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional PET reclamation systems). Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PET yield and avoid contamination.

**DIRECT PRINTING/DECORATION** Presently, all direct printing other than date coding, either for product labeling or decoration, contaminates recycled PET in conventional reclamation systems and should be avoided. The inks used in direct printing may bleed ink or otherwise discolor the PET during processing, or introduce incompatible contaminants. In either case, the value of the PET for recycling is diminished or eliminated.

**BARRIER LAYERS, MONOMERS, COATINGS & ADDITIVES** Some PET bottle designs require the use of barrier layers, additional monomers, coatings or additives to meet the requirements of specific product applications. Additives to PET bottles, including scavengers, which cause the PET to discolor and/or haze after remelting and solid stating, should be avoided unless means are readily and economically available to minimize the effects. Similarly, blends of PET and other resins are undesirable unless they are compatible with PET recycling. This includes not melting or softening at PET dryer operations temperatures of up to 175°C (350°F).

In general, the use of non-PET layers and coatings are undesirable and should be avoided, **unless** they are compatible with PET or are easily separable from PET in conventional recycling systems. The use of EVOH, nylon-based (e.g., nylon-6, MXD6), epoxies, amorphous or “diamond-like” carbon, and silicon oxide barrier layers or coatings is currently tolerated by most reclaimers provided the layers/coatings readily separate and can be isolated or have been shown not to be a problem for the reclaiming process or reclaimed product. When used, their content should be minimized to the greatest extent possible to maximize PET yield, limit potential contamination, and reduce separation costs. The use of non-PET layers and coatings can drastically reduce the recyclability of PET.

Based on public product performance claims, it appears that the use of degradable additives may result in shortening the useful life of the bottles of which they are a part and therefore affect the ability of such bottles to be recycled. Of equal or greater concern, the effect of having degradable additives in the recycling stream on reclaiming processes and the technical performance of recycled resin is currently unclear. Degradable additives should not be used without an evaluation confirming that their
expected use will not materially impair the full service life and properties, including successful recycle and durability, for the next use of the recycled bottle. (The APR’s Champions for Change Cooperative Testing Program invites consumer product, plastic bottle and bottle component manufacturers to work with APR member companies to determine whether new modifications to a regularly recycled plastic bottle will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents form a necessary, but not sufficient, basis for test program design for degradable additives. Aging under specific environmental exposure is needed for the technical assessment of the initial postconsumer bottle. Additionally, the next use applications must be tested under conditions of specific aging and environmental exposure to assure full service life and subsequent next use recycling.)

BASECUPS/ADHESIVES The use of base cups is undesirable and should be avoided, as they reduce PET yield and increase separation costs. If base cups are used, the use of unfilled HDPE or clear PET is preferred to all other materials. If glued on, base cup adhesives should be water soluble or dispersible at 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PET regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. (The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional PET reclamation systems). Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PET yield and avoid contamination.

OTHER ATTACHMENTS The use of any other attachments is discouraged, as they reduce base resin yield and increase separation costs. If any other attachments to a bottle are used, they should be made from HDPE or clear PET. The use of welded attachments should be avoided. The use of non-PET attachments, such as handles, should not be adhesively bonded to the bottle and should readily separate from the bottle in conventional PET reclamation systems. If adhesives are used to affix attachments, they should be water soluble or dispersible at 140°F to 180°F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PET regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. (The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional PET reclamation systems). Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PET yield and avoid contamination.

The use of RFID’s (radio frequency identification devices) on bottles, labels or closures is discouraged and should be avoided unless they are compatible with PET recycling and are demonstrated not to create any disposal issues based on their material content. The use of RFID’s is discouraged as it limits PET yield, introduces potential contamination, and increases separation costs.

Silicone polymer closure parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.
NON-DETACHING COMPONENTS  The use of non-detaching bottle components, including monomers, which are not made from PET, must be either compatible with or easily separable from PET in conventional recycling systems, and must not adversely affect end-use product performance.

POSTCONSUMER CONTENT  The use of postconsumer PET in bottles is encouraged, whenever possible.

RESIN IDENTIFICATION CODE, RIC  The use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged. Meeting the APR Critical Guidance for a specific resin may be used as a supplemental demonstration of proper RIC assignment.
PET Thermoformed Packages

PET Thermoformed packages are produced by extruding a sheet, then heating that sheet to a pliable forming temperature and then usually assisted by a vacuum formed by a mold and trimmed into a package or product. These packages include but are not limited to cups, baskets, clamshells, trays, covers, egg cartons, lids and blister pack. There is also a growing category of containers made from folded PET sheet (like greeting card and Christmas ornament boxes) that should also be included in this category.

A wide range of PET materials are used to produce either the sheet from which the packages are formed or in some cases from which the packages are manufactured in-line. These materials include:

- Prime bottle resin from domestic producers
- Off-spec bottle resin from domestic producers
- Amorphous chip and pellet from domestic producers
- All of the above from foreign producers
- Industrial regrinds from sheet performs and bottles
- Reprocessed industrial waste
- Post consumer RPET flake and pellet produced by domestic reclaimers
- Post consumer RPET flake and pellet produced by foreign reclaimers

Despite the variety of these potential feedstocks, customer requirements with respect to clarity and performance, in general, demand a quality level of the raw materials used be comparable to bottles. A study commissioned by NAPCOR and APR to examine this issue found that in fact, at aggressive levels of blends of bottle and thermoform recyclate the resins passed APR Application Guidance test protocols.

However, APR also recognizes that labels, adhesives, additives and treatments used either during the manufacturing or use of the package, or in the case of processed scrap during a previous intended purpose, can have serious impacts on the quality of the post consumer RPET produced. What follows are general guidelines to consider when making decisions with respect to a PET thermoformed package. This is followed by the Thermoform Guidance Document that will allow interested parties to test the impacts on the recycling stream of a particular package and finally a protocol that tests whether a particular label and adhesive is compatible with the PET recycling stream.

Guidance

The basic design guidance to consider when making material choice for thermoforms is to consider its general compatibility with the base resin (PET) or the removal efficiency in conventional water-based separation systems that separate plastics by density. Attachments may include labels, seals, coatings, and layers. PET has a density or specific gravity greater than 1.0 (the density of water) and will sink in water-based
separation systems. For efficient separation and removal in conventional sink/float separation systems, attachments should be made from materials with a density less than 1.0 or be otherwise compatible with PET in the reclamation process. Non-adhering materials with a density less than 1.0 will float in these systems and can be separated easily from the PET.

The use of non-PET polyesters must be confirmed not to interfere with the recycling process or impair the use of the recyclate into applications served by recycled PET. The PET Thermoform Guidance Document should be used for the confirmation.

**COLOR**
Traditionally, unpigmented PET has the highest value and the widest variety of end-use applications. All other colors, transparent and opaque, should be avoided.

Inclusion of nucleating agents, hazing agents, fluorescers, and other additives for visual and technical effects should be considered highly questionable and should be examined specifically per the reclaiming industry’s PET Thermoform Guidance Documents for impact on the overall PET recycling stream. *(Thermoform decision makers should test their opaque, translucent, and unusual transparent colors through Guidance testing programs to determine if the selections of color will act detrimentally on the reclaiming industry and if markets may be available for such colors.)*

**PVC and/or PLA ATTACHMENTS**
The use of PVC or PLA attachments of any kind on PET packages is undesirable and should be scrupulously avoided. This includes thermoforms of PVC and/or PLA that may be visually confused with PET thermoforms. Very small amounts of PVC or PLA (in the parts-per-million range) can severely contaminate and render large amounts of PET useless for most recycling applications. In addition, PVC and PLA are very difficult to separate from PET in conventional water-based density separation systems, due to similar densities (densities greater than 1.0) that cause both to sink in these systems.

**OTHER MATERIALS IN OR ON PET THERMOFORM PACKAGES**
Plastic enclosures, liners, and labels may be included in thermoform packaging. All such items should be either completely compatible with the clear PET thermoform (no printing, made of the same PET resin) or made of materials that float in water. Such materials include polyethylene and polypropylene. The use of PVC should be scrupulously avoided. The use of other materials with specific gravities greater than 1.0, including polystyrene and polylactic acid (PLA) and glycol-modified PET (PETG) should be avoided unless means are generally available to remove such materials from the stream of PET recyclable material. Metals and metal foils and metalized substrates that sink in water should be avoided. Paper and molded pulp should be avoided as the PET reclamation process can disaggregate to fibers which contaminate PET. Non-pulping paper labels should be tested per the Protocol for Evaluating PET Thermoform Labels and Adhesives for Compatibility with PET Recycling to check of effects.

**INKS & ADHESIVES**
Some label inks bleed color when agitated in hot water and can discolor PET regrind in the reclamation process, diminishing or eliminating its value for recycling. The APR
and NAPCOR have developed a testing protocol to assist label manufacturers in evaluating whether a label ink will bleed in conventional PET reclaiming systems. Label inks must be chosen that do not bleed color when tested under this protocol. The use of label inks that bleed or discolor PET moldings should be scrupulously avoided. The APR Protocol for Evaluating PET Thermoform Labels and Adhesives for Compatibility with PET Recycling, Appendix A should be used to examine candidate inks, printing, and decoration.

Pressure sensitive labels should separate from PET regrind in the hot caustic water wash step. Label adhesives should be water soluble or dispersible at temperatures between 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PET regrind and embed unwanted contaminants and can discolor PET upon melting. The use of adhesive types which discolor PET upon melting are discouraged. Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PET yield and avoid contamination. The APR Protocol for Evaluating PET Thermoform Labels and Adhesives for Compatibility with PET Recycling should be used to examine candidate adhesives. Paper substrates that pulp in the PET washing conditions are not favored. Oriented polypropylene labels are favored as having minimal effect on PET recycling so long as they float in water.

**DIRECT PRINTING/DECORATION**

The impacts from the use of inks for direct printing on cups and other packages should be evaluated using the APR Protocol for Producing PET Flake for Evaluation and Evaluating for Discoloration from “Bleeding Labels”. Direct printing that cannot be removed or that stains the flake after removal is undesirable and should be avoided. See Bleeding labels protocol for a more complete discussion and details.

**THERMOFORM ADDITIVES, MODIFIERS, AND ADDITIONS**

Some PET thermoform designers use additives to meet the requirements of specific product applications. Additives to PET thermoforms which cause the PET to discolor, fluoresce, and/or haze after remelting and solid stating, should be avoided unless means are readily and economically available to minimize the effects. Similarly, blends of PET and other resins are undesirable unless they are compatible with PET recycling.

In general, the use of non-PET layers and coatings are undesirable and should be avoided, unless they are compatible with PET or are easily separable from PET in conventional recycling systems. This includes sealing layers. When used, their content should be minimized to the greatest extent possible to maximize PET yield, limit potential contamination, and reduce separation costs. The use of non-PET layers and coatings can drastically reduce the recyclability of PET.

Recognized additives used for thermoforms include the following and each should be examined by the PET Thermoform Guidance Document to show the effects on PET recycling:

1. Denesting agents
2. Anti-stat agents
3. Anti-blocking agents
4. Anti-fogging agents
5. UV barrier or stabilizer agents
6. Anti-slip agents
7. Heat receptors
8. Lubricants

Optical brighteners can create an unacceptable fluorescence for next uses of recycled thermoforms containing the brighteners. Optical brighteners should be avoided. Based on public product performance claims, it appears that the use of degradable additives may result in shortening the useful life of the items made from recycled PET thermoforms. Degradable additives (photo, oxo, or bio) should not be used without an evaluation confirming that their expected use will not materially impair the full service life and properties, including successful recycle and durability, for the next use of recycled PET.

(Aging under specific environmental exposure is needed for the technical assessment of the initial postconsumer thermoform. Additionally, the next use applications must be tested under conditions of specific aging and environmental exposure to assure full service life and subsequent next use recycling. Testing should be conducted per APR’s Degradable Additives and PET Recycling Technical Compatibility Testing Guidance.

The use of RFID’s (radio frequency identification devices) on thermoforms is discouraged and should be avoided unless they are compatible with PET recycling and are demonstrated not to create any disposal issues based on their material content. The use of RFID’s is discouraged as it limits PET yield, introduces potential contamination, and increases separation costs.

Silicone polymer parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.

**POSTCONSUMER CONTENT**
The use of postconsumer PET in thermoforms is encouraged, whenever possible.

**RESIN IDENTIFICATION CODE, RIC**
The use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged. Meeting the APR Critical Guidance for a specific resin may be used as a supplemental demonstration of proper RIC assignment.
Natural HDPE Milk & Water Bottles (unpigmented homopolymer resin)

The basic design for recycling guideline to consider when making material choices for any attachment to the bottle is to consider its general compatibility with the base resin (homopolymer HDPE) or the removal efficiency in conventional water-based separation systems that separate plastics by density. Attachments may include closures, closure liners, inserts, labels, pour spouts, handles, sleeves, safety seals, coatings, and layers. HDPE has a density or specific gravity less than 1.0 (the density of water) and will float in these systems. For efficient separation and removal in conventional sink/float separation systems, attachments should be made from materials with a density greater than 1.0 or be otherwise compatible with HDPE in the reclamation process. Materials with a density greater than 1.0 will sink in these systems and can be separated easily from the HDPE. (The density range of key plastic materials can be found on page 8).

COLOR Unpigmented, homopolymer HDPE used for milk and water bottles has the highest value and widest variety of end-use applications. Its lack of pigmentation makes it easy and economical to sort and separate from other plastic bottles. The use of pigments in homopolymer HDPE bottles is undesirable and should be avoided.

CLOSURES/CLOSURE LINERS Plastic closures made from HDPE, LDPE, or PP are preferred to all others. Also preferred, are closure systems that contain no liners and leave no residual rings, or other attachments, on the bottle after the closure is removed. For these reasons, ‘snap-on’ caps are preferred to ‘screw-on’ caps. The use of PVC for closures or closure liners is undesirable and should be avoided. The use of metal closures is undesirable and should be avoided as they are more difficult and more costly to remove in conventional HDPE reclamation systems compared to the preferred closure systems (HDPE, LDPE, or PP). The sum of PP and LDPE closure and attachments should be limited to less than 5% of the total bottle weight. Closures made from steel are undesirable and should be avoided. Silicone polymer closure parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.

SLEEVES & SAFETY SEALS If tamper resistance is required in specific product applications, it should be an integral design feature of the bottle. The use of tamper-resistant or tamper-evident sleeves or seals is discouraged as they can act as contaminants if they do not completely detach from the bottle, or are not easily removed in conventional separation systems. If sleeves or safety seals are used, they should be designed to completely detach from the bottle, leaving no remains on the bottle. Shrink sleeves are preferred to adhered labels. Shrink sleeves made from PE or PP are preferred. The use of PVC sleeves or safety seals is undesirable and should be avoided. Foil safety seals that leave foil or remnants or attaching adhesive on the HDPE bottle should be avoided.

LABELS PP, OPP, HDPE, MDPE, LDPE, LLDPE, or PS label stock is preferred to all
other label materials. The preferred label systems are shrink sleeve labels that require no adhesive, or those that incorporate the label directly on the closure. Paper labels are undesirable and should be avoided as they can increase contamination in the HDPE due to fiber and adhesive carry-over through the reclamation process. Similarly, metallized labels increase contamination and separation costs and should be avoided. The use of PVC labels is undesirable and should be avoided. Full bottle sleeves should be so designed that automatic sorting equipment can properly identify the resin used to make the bottle.

**INKS & ADHESIVES** Inks must be chosen that do not bleed color when agitated in water. Label inks that bleed and can discolor unpigmented HDPE regrind in the reclamation process, diminishing or eliminating its value for recycling. The use of label inks that bleed should be scrupulously avoided. (The APR has developed a testing protocol to assist label manufacturers in evaluating whether a label ink will bleed in conventional HDPE reclamation systems).

The use of “hot melt” adhesives is undesirable and should be avoided unless the adhesive readily separates from the plastic and does not cause problems in the reclaiming process. Label adhesives should be water soluble or dispersible at temperatures between 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the HDPE regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. (The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional HDPE reclamation systems). Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize HDPE yield and avoid contamination.

**DIRECT PRINTING/DECORATION** Presently, all direct printing other than date coding, either for product labeling or decoration, contaminates recycled unpigmented, HDPE homopolymer in conventional reclamation systems. The inks used in direct printing may bleed ink or otherwise discolor the HDPE during processing, or introduce incompatible contaminants. In either case, the value of the HDPE for recycling is diminished or eliminated.

**LAYERS** While unpigmented, homopolymer HDPE bottles generally do not use a multi-layer construction, it is possible that future bottle designs might require the use of layers for specific product applications. The use layers that are not made from unpigmented, homopolymer HDPE is undesirable and should be avoided, unless they are compatible with or easily separable from HDPE in conventional recycling systems. If layers must be used, their content should be minimized to the greatest extent possible to maximize HDPE yield and reduce potential contamination and separation costs. (The APR’s Champions for Change cooperative Testing Program invites consumer product, plastic bottle and bottle component manufacturers to work with APR member companies to determine whether new modifications to a regularly recycled plastic bottle will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents should be the basis for test program design)
**ADDITIVES** Based on public product performance claims, it appears that the use of degradable additives may result in shortening the useful life of the bottles of which they are a part and therefore affect the ability of such bottles to be recycled. Of equal or greater concern, the effect of having degradable additives in the recycling stream on reclaiming processes and the technical performance of recycled resin is currently unclear. Degradable additives should not be used without an evaluation confirming that their expected use will not materially impair the full service life and properties, including successful recycle and durability, for the next use of the recycled bottle. *(The APR’s Champions for Change Cooperative Testing Program invites consumer product, plastic bottle and bottle component manufacturers to work with APR member companies to determine whether new modifications to a regularly recycled plastic bottle will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents form a necessary, but not sufficient, basis for test program design for degradable additives. Aging under specific environmental exposure is needed for the technical assessment of the initial postconsumer bottle. Additionally, the next use applications must be tested under conditions of specific aging and environmental exposure to assure full service life and subsequent next use recycling.)*

**OTHER ATTACHMENTS** Other attachments made from HDPE are preferred to all others as the use of non-HDPE attachments reduce base resin yield and increase separation costs. Other attachment may include handles, inserts and pour spouts, in addition to others that might be developed. Non-HDPE attachments should not be adhesively bonded to the bottle and must readily separate from the bottle in conventional HDPE reclamation systems. If non-HDPE attachments are added to a bottle, they should be made from materials with a density greater than 1.0 that will easily separate from HDPE in conventional separation systems with the exception of PVC, which is undesirable and should be avoided. The use of PP or LDPE attachments, if necessary, and closures should be limited to less than 5% of the total bottle weight. Higher percentages can contaminate the HDPE for many recycling applications, as these materials are difficult to separate from HDPE in conventional systems. The uses of attachments that contain metallic components are discouraged and should be avoided. If adhesives are used to affix attachments, they should be water soluble or dispersible at 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the HDPE regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. *(The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional HDPE reclamation systems.)* Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize HDPE yield and avoid contamination.

Silicone polymer closure parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.

**POSTCONSUMER CONTENT** The use of postconsumer HDPE in bottles is encouraged, whenever possible.
RESIN IDENTIFICATION CODE, RIC  The use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged. Meeting the APR Critical Guidance for a specific resin may be used as a supplemental demonstration of proper RIC assignment.
Pigmented HDPE Laundry Detergent & Household Chemical Bottles (copolymer resin)

The basic design for recycling guideline to consider when making material choices for any attachment to the bottle is to consider its general compatibility with the base resin (copolymer HDPE) or the removal efficiency in conventional water-based separation systems that separate plastics by density. Attachments may include closures, closure liners, inserts, labels, pour spouts, handles, sleeves, safety seals, coatings, and layers. HDPE has a density less than 1.0 (the density of water) and will float in these systems. For efficient separation and removal in conventional sink/float separation systems, attachments should be made from materials with a density greater than 1.0 or be otherwise compatible with HDPE in the reclamation process. Materials with a density greater than 1.0 will sink in these systems and can be separated easily from the HDPE. (The density range of key plastic materials can be found on page 8).

**COLOR**  In general, copolymer HDPE bottles are pigmented. However, there are some product applications that use unpigmented copolymer HDPE bottles. This presents a challenge for some plastic reclaimers that use pigmentation as the basis by which they distinguish and sort copolymer HDPE from homopolymer HDPE bottles. In multi-layer HDPE bottle designs, the use of inner layers of the same color as the surface layer is preferred to maximize recyclability. However, inner layers of different color than the surface layer are tolerated in many conventional reclamation systems.

**CLOSURES/CLOSURE LINERS**  Plastic closures made from HDPE, LDPE, or PP are preferred to all others. Also preferred, are closure systems that contain no liners and leave no residual rings, or other attachments, on the bottle after the closure is removed. The use of closures that are the same color as the bottle is desirable. The use of PVC for closures or closure liners is undesirable and should be avoided. The use of metal closures is undesirable and should be avoided as they are more difficult and more costly to remove in conventional HDPE reclamation systems compared to the preferred closure systems (HDPE, LDPE, or PP). The sum of PP and LDPE closure and attachments should be limited to less than 5% of the total bottle weight. **Closures made from steel are undesirable and should be avoided.** Silicone polymer closure parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.

**SLEEVES & SAFETY SEALS**  If tamper resistance is required in specific product applications, it should be an integral design feature of the bottle. The use of tamper-resistant or tamper-evident sleeves or seals is discouraged as they can act as contaminants if they do not completely detach from the bottle, or are not easily removed in conventional separation systems. If sleeves or safety seals are used, they should be designed to completely detach from the bottle, leaving no remains on the bottle. Shrink sleeves are preferred to adhered labels. Shrink sleeves made from PE or PP are preferred. The use of PVC sleeves or safety seals is undesirable and should be avoided. **Foil safety seals that leave foil or remnants or attaching adhesive on the HDPE bottle should be**
avoided.

**LABELS** PP, OPP, HDPE, MDPE, LDPE, LLDPE, and PS label stock are preferred to all other label materials. The preferred labels systems are shrink sleeve labels that require no adhesive. Paper labels are undesirable and should be avoided as they can increase contamination in the HDPE due to fiber and adhesive carry-over through the reclamation process. Similarly, metallized labels increase contamination and separation costs and should be avoided. The use of PVC labels is undesirable and should be avoided. Full bottle sleeves should be so designed that automatic sorting equipment can properly identify the resin used to make the bottle.

**INKS & ADHESIVES** Inks must be chosen that do not bleed color when agitated in water. Label inks that bleed and can discolor the HDPE regrind in the reclamation process, diminishing or eliminating its value for recycling. The use of label inks that bleed should be scrupulously avoided. *(The APR has developed a testing protocol to assist label manufacturers in evaluating whether a label ink will bleed in conventional HDPE reclamation systems).*

The use of “hot melt” adhesives is undesirable and should be avoided unless the adhesive readily separates from the plastic and does not cause problems in the reclaiming process. Label adhesives should be water soluble or dispersible at temperatures between 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the HDPE regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. *(The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional HDPE reclamation systems).* Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize HDPE yield and avoid contamination.

**DIRECT PRINTING/DECORATION** Direct printing other than date coding, either for product labeling or decoration, can contaminate recycled HDPE copolymer in conventional reclamation systems. The inks used in direct printing may bleed ink or otherwise discolor the HDPE during processing, or introduce incompatible contaminants. In either case, the value of the HDPE for recycling is diminished or eliminated. Testing should be conducted to confirm no adverse impact on the reclaiming process or product.

**LAYERS** Some pigmented, HDPE bottle designs require the use of layers for specific product applications. In multi-layer HDPE bottle designs, the use of inner layers of the same color as the surface layer is preferred to maximize recyclability. However, inner layers of different color than the surface layer are tolerated in many conventional reclamation systems. The use of non-HDPE layers is undesirable and should be avoided, *unless* they are compatible with or easily separable from HDPE in conventional recycling systems. Current HDPE recycling systems can tolerate the use of EVOH layers, provided the total EVOH concentration is minimized to the greatest extent possible. Similarly, MXD6 and other nylon-based layers are tolerated, particularly if the layers readily separate from the HDPE in conventional reclamation systems. If layers must be used, their content should be minimized to the greatest extent possible to maximize HDPE yield and reduce potential contamination and separation costs. *(The APR’s Champions*
for Change Cooperative Testing Program invites consumer product, plastic bottle, and bottle component manufacturers to work with APR member companies to determine whether new modifications to a regularly recycled plastic bottle will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents should be the basis for test program design.

ADDITIVES  The use of additives such as calcium carbonate, talc, or other fillers in concentrations that alter the density to greater than that of water (causing the HDPE plastic sinks in water), or alter properties of the HDPE regrind are undesirable and should be avoided.

Based on public product performance claims, it appears that the use of degradable additives may result in shortening the useful life of the bottles of which they are a part and therefore affect the ability of such bottles to be recycled. Of equal or greater concern, the effect of having degradable additives in the recycling stream on reclaiming processes and the technical performance of recycled resin is currently unclear. Degradable additives should not be used without an evaluation confirming that their expected use will not materially impair the full service life and properties, including successful recycle and durability, for the next use of the recycled bottle. (The APR’s Champions for Change Cooperative Testing Program invites consumer product, plastic bottle and bottle component manufacturers to work with APR member companies to determine whether new modifications to a regularly recycled plastic bottle will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents form a necessary, but not sufficient, basis for test program design for degradable additives. Aging under specific environmental exposure is needed for the technical assessment of the initial postconsumer bottle. Additionally, the next use applications must be tested under conditions of specific aging and environmental exposure to assure full service life and subsequent next use recycling.)

OTHER ATTACHMENTS  Other attachments made from HDPE are preferred to all others as the use of non-HDPE attachments reduce base resin yield and increase separation costs. Other attachment may include handles, inserts and pour spouts, in addition to others that might be developed. Non-HDPE attachments should not be adhesively bonded to the bottle and must readily separate from the bottle in conventional HDPE reclamation systems. If non-HDPE attachments are added to a bottle, they should be made from materials with a density greater than 1.0 that will easily separate from HDPE in conventional separation systems with the exception of PVC, which is undesirable and should be avoided. The use of PP or LDPE attachments, if necessary, and closures should be limited to less than 5% of the total bottle weight. Higher percentages can contaminate the HDPE for many recycling applications, as these materials are difficult to separate from HDPE in conventional systems. If pour spouts are added to a bottle, they should be designed to leave no product residue and allow for complete removal of product contents when the bottle is emptied. The uses of attachments that contain metallic components are discouraged and should be avoided. If adhesives are used to affix attachments, they should be water soluble or dispersible at 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the HDPE regrind and
embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided.

*(The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional HDPE reclamation systems).* Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize HDPE yield and avoid contamination.

Silicone polymer closure parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.

**POSTCONSUMER CONTENT** The use of postconsumer HDPE in bottles is encouraged, whenever possible.

**RESIN IDENTIFICATION CODE, RIC** The use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged. Meeting the APR Critical Guidance for a specific resin may be used as a supplemental demonstration of proper RIC assignment.
Polypropylene (PP) Bottles

The basic design for recycling guideline to consider when making material choices for any attachment to the bottle is to consider its general compatibility with the base resin (PP) or the removal efficiency in conventional water-based separation systems that separate plastics by density. Attachments may include closures, closure liners, inserts, labels, pour spouts, handles, sleeves, safety seals, coatings, and layers. PP has a density less than 1.0 (the density of water) and will float in these systems. For efficient separation and removal in conventional sink/float separation systems, attachments should be made from materials with a density greater than 1.0 or be otherwise compatible with PP in the reclamation process. Materials with a density greater than 1.0 will sink in these systems and can be separated easily from the HDPE. (The density range of key plastic materials can be found on page 8).

**COLOR** The use of unpigmented PP bottles is generally preferred to pigmented bottles as the unpigmented bottles have a greater number of potential applications.

**CLOSURES/CLOSURE LINERS** Plastic closures made from HDPE, LDPE, or PP are preferred to all others. Also preferred, are closure systems that contain no liners and leave no residual rings, or other attachments, on the bottle after the closure is removed. The use of closures that are unpigmented or the same color as the bottle is desirable, if practical. The use of PVC for closures or closure liners is undesirable and should be avoided. The use of metal closures is undesirable and should be avoided as they are more difficult and more costly to remove in conventional PP reclamation systems compared to the preferred closure systems (HDPE, LDPE, or PP). **Closures made from steel are undesirable and should be avoided.** Silicone polymer closure parts are discouraged as they may present significant technical problems in the process of recycling and to the usefulness of the recycled plastic.

**SLEEVES & SAFETY SEALS** If tamper resistance is required in specific product applications, it should be an integral design feature of the bottle. The use of tamper-resistant or tamper-evident sleeves or seals is discouraged as they can act as contaminants if they do not completely detach from the bottle, or are not easily removed in conventional separation systems. If sleeves or safety seals are used, they should be designed to completely detach from the bottle, leaving no remains on the bottle. Shrink sleeves are preferred to adhered labels. Shrink sleeves made from PE or PP are preferred. The use of PVC sleeves or safety seals is undesirable and should be avoided. Foil safety seals that leave foil or remnants or attaching adhesive on the PP bottle should be avoided.

**LABELS** PP, OPP, HDPE, MDPE, LDPE, LLDPE, or PS label stock is preferred to all other label materials. Metallized labels increase contamination and separation costs and should be avoided. The use of PVC labels is undesirable and should be avoided. Paper labels are undesirable and should be avoided as they can increase contamination in the PP due to fiber and adhesive carry-over through the reclamation process. Full bottle sleeves should be so designed that automatic sorting equipment can properly identify the resin
used to make the bottle.

**INKS & ADHESIVES**  Inks must be chosen that do not bleed color when agitated in water. Label inks that bleed and can discolor the PP regrind in the reclamation process, diminishing or eliminating its value for recycling. The use of label inks that bleed should be scrupulously avoided. *(The APR has developed a testing protocol to assist label manufacturers in evaluating whether label ink will bleed in conventional PP reclamation systems).*

The use of “hot melt” adhesives is undesirable and should be avoided unless the adhesive readily separates from the plastic and does not cause problems in the reclaiming process. **Label adhesives should be water soluble or dispersible** at temperatures between 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PP regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. *(The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional reclamation systems).* Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PP yield and avoid contamination.

**DIRECT PRINTING/DECORATION**  Presently, all direct printing other than date coding, either for product labeling or decoration, contaminates recycled PP in conventional reclamation systems. The inks used in direct printing may bleed ink or otherwise discolor the PP during processing, or introduce incompatible contaminants. In either case, the value of the PP for recycling is diminished or eliminated.

**LAYERS**  Some PP bottle designs require the use of layers for specific product applications. The use of non-PP layers is undesirable and should be avoided, unless they are compatible with or easily separable from PP in conventional recycling systems. Current PP recycling systems can tolerate the use of EVOH layers. If layers must be used, their content should be minimized to the greatest extent possible to maximize PP yield and reduce potential contamination and separation costs. *(The APR's Champions for Change Cooperative Testing Program invites consumer product, plastic bottle and bottle component manufacturers to work with APR member companies to determine whether new modifications to a regularly recycled plastic bottle will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents should be the basis for test program design)*

**ADDITIVES**  The use of nucleated PP is discouraged and should be avoided as nucleation restricts the use of the postconsumer PP in some applications.

Based on public product performance claims, it appears that the use of degradable additives may result in shortening the useful life of the bottles of which they are a part and therefore affect the ability of such bottles to be recycled. Of equal or greater concern, the effect of having degradable additives in the recycling stream on reclaiming processes and the technical performance of recycled resin is currently unclear. Degradable additives should not be used without an evaluation confirming that their expected use will not materially impair the full service life and properties, including
successful recycle and durability, for the next use of the recycled bottle. *(The APR’s Champions for Change Cooperative Testing Program invites consumer product, plastic bottle and bottle component manufacturers to work with APR member companies to determine whether new modifications to a regularly recycled plastic bottle will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents form a necessary, but not sufficient, basis for test program design for degradable additives. Aging under specific environmental exposure is needed for the technical assessment of the initial postconsumer bottle. Additionally, the next use applications must be tested under conditions of specific aging and environmental exposure to assure full service life and subsequent next use recycling.)*

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

**OTHER ATTACHMENTS** Other attachments made entirely of PP are preferred, as non-polypropylene attachments reduce base resin yield and increase separation costs. Other attachment may include handles, inserts and pour spouts, in addition to others that might be developed. The use of non-PP attachments should not be adhesively bonded to the bottle and should readily separate from the bottle in conventional PP reclamation systems. If attachments are added to a bottle, they should be made from 1) materials with a density greater than 1.0, with the exception of PVC, which is undesirable and should be avoided, that will easily separate from PP in conventional separation systems or, 2) compatible materials such as pigmented, or preferably unpigmented PP. The use of HDPE or LDPE attachments, if necessary, should be limited to less than 5% of the total bottle weight. Higher percentages can contaminate the PP for many recycling applications, as these materials are difficult to separate from PP in conventional systems. If pour spouts are added to a bottle, they should be designed to leave no product residue and allow for complete removal of product contents when the bottle is emptied. The uses of attachments that contain metallic components are discouraged and should be avoided. If adhesives are used to affix attachments, they should be water soluble or dispersible at 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PP regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided.

*(The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional reclamation systems).* Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PP yield and avoid contamination.

Silicone polymer closure parts are discouraged due to the technically significant challenges they present to the process of recycling and the usefulness of the recycled plastic.

**POSTCONSUMER CONTENT** The use of postconsumer PP in bottles is encouraged, whenever possible.
RESIN IDENTIFICATION CODE, RIC  The use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged. Meeting the APR Critical Guidance for a specific resin as a supplemental demonstration of proper RIC assignment.
Polyvinyl Chloride (PVC) Bottles

PVC bottles are present in the post-consumer collected stream of plastic bottles at such low levels that the bottles are considered a contaminant to the recycling of other bottles. Because of the contamination problem, APR finds the use of PVC bottles undesirable if those bottles are included with bales of PET or HDPE bottles. If a bottle designer or specifier finds that PVC must be the resin of choice for a given application, APR recommends the following in hopes that PVC bottle recycling may someday be a commercial opportunity:

The basic design for recycling guideline to consider when making material choices for any attachment to the bottle is to consider its general compatibility with the base resin (PVC) or the removal efficiency in conventional water-based separation systems that separate plastics by density. Attachments may include closures, closure liners, base cups, inserts, labels, pour spouts, handles, sleeves, safety seals, coatings, and layers. PVC has a density greater than 1.0 (the density of water) and will sink in these systems. For efficient separation and removal in conventional sink/float separation systems, attachments should be made from materials with a density less than 1.0 or be otherwise compatible with PVC in the reclamation process. Materials with a density less than 1.0 will float in these systems and can be separated easily from the PVC. (The density range of key plastic materials can be found on page 8).

PET ATTACHMENTS  The use of PET attachments 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 and render large amounts of PVC useless for most recycling applications. In addition, PET is very difficult to separate from PVC in conventional water-based density separation systems, due to similar densities (> 1.0) that cause both to sink in these systems.

CLOSURES/CLOSURE LINERS  Plastic closures made from HDPE, LDPE, or PP are preferred to all others. Also preferred, are closure systems that contain no liners and leave no residual rings, or other attachments, on the bottle after the closure is removed. The use of PET for closures or closure liners is undesirable and should be scrupulously avoided. The use of metal closures is undesirable and should be avoided as they are more difficult and more costly to remove in conventional reclamation systems compared to the preferred closure systems (HDPE, LDPE, or PP). Closures made from steel are undesirable and should be avoided.

SLEEVES & SAFETY SEALS  If tamper resistance is required in specific product applications, it should be an integral design feature of the bottle. The use of tamper resistant or tamper evident sleeves or seals is discouraged as they can act as contaminants if they do not completely detach from the bottle, or are not easily removed in conventional separation systems. If sleeves or safety seals are used, they should be designed to completely detach from the bottle. Shrink sleeves are preferred when sleeves are necessary.
LABELS  PP, OPP, HDPE, MDPE, LDPE, LLDPE, or PVC label stocks are preferred to all other label materials. The preferred label systems are those that incorporate the label on the closure, followed by shrink sleeve labels that require no adhesive. Metallized labels increase contamination and separation costs and should be avoided. The use of PET labels is undesirable and should be scrupulously avoided. Full bottle sleeves should be so designed that automatic sorting equipment can properly identify the resin used to make the bottle.

INKS & ADHESIVES  Inks must be chosen that do not bleed color when agitated in hot water, as they can discolor the PVC regrind during the reclamation process, diminishing or eliminating its value for recycling. The use of label inks that bleed should be scrupulously avoided. (The APR has developed a testing protocol to assist label manufacturers in evaluating whether a label ink will bleed in conventional PP reclamation systems).

The use of “hot melt” adhesives is undesirable and should be avoided unless the adhesive readily separates from the plastic and does not cause problems in the reclaiming process. Label adhesives should be water soluble or dispersible at temperatures between 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PVC regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. (The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional reclamation systems). Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PVC yield and avoid contamination.

DIRECT PRINTING/DECORATION Presently, all direct printing other than date coding, either for product labeling or decoration, contaminates recycled PVC in conventional reclamation systems. The inks used in direct printing may bleed ink or otherwise discolor the PVC during processing, or introduce incompatible contaminants. In either case, the value of the PVC for recycling is diminished or eliminated.

OTHER ATTACHMENTS The use of any other attachments is discouraged, as they reduce base resin yield and increase separation costs. If any other attachments to a bottle are used, they should be made from HDPE or clear PVC. If adhesives are used to affix attachments, they should be water soluble or dispersible at 140°F to 180°F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PVC regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. (The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional reclamation systems). Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PVC yield and avoid contamination.

POSTCONSUMER CONTENT The use of postconsumer PVC in bottles is encouraged, whenever possible.
RESIN IDENTIFICATION CODE, RIC  The use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged. Meeting the APR Critical Guidance for a specific resin may be used as a supplemental demonstration of proper RIC assignment.
Bottles Made from Resins Other than PET, HDPE, or PP
(which are the resins deliberately sought for commercial recycling)

Given the established plastic bottle reclaiming infrastructure, bottles made from resins other than PET, HDPE, or PP are generally likely to introduce contamination, or otherwise have a negative impact on the current postconsumer plastic bottle recycling stream and should be avoided unless compatibility in reclaiming, processing and end-product manufacturing can be demonstrated. (The APR’s Champions for Change Cooperative Testing Program invites consumer product, plastic bottle and bottle component manufacturers to work with APR member companies to determine whether new bottle types will impact conventional recycling systems prior to introducing the new bottle.) If new bottle types are introduced, they should follow the same general design for recycling guidelines established for other resin types as APR hopes those bottles may someday provide commercial recycling opportunities.

CLOSURES/CLOSURE LINERS Plastic closures made from PE or PP are preferred to all others. Also preferred, are closure systems that contain no liners and leave no residual rings, or other attachments, on the bottle after the closure is removed. The use of closures that are unpigmented or the same color as the bottle is desirable. The use of metal closures is undesirable and should be avoided as such closures are more difficult and more costly to remove in conventional reclamation systems compared to the preferred closure systems (PE or PP). Closures made from steel are undesirable and should be avoided.

SLEEVES & SAFETY SEALS If tamper resistance is required in specific product applications, it should be an integral design feature of the bottle. The use of tamper-resistant or tamper-evident sleeves or seals is discouraged as they can act as contaminants if they do not completely detach from the bottle, or are not easily removed in conventional separation systems. If sleeves or safety seals are used, they should be designed to completely detach from the bottle, leaving no remains on the bottle. Shrink sleeves are preferred to adhered labels. Shrink sleeves made from PE or PP are preferred. The use of PVC sleeves or safety seals is undesirable and should be avoided. Foil safety seals that leave foil or remnants or attaching adhesive on the PP bottle should be avoided.

COLOR Unpigmented bottles generally have the highest value and the widest variety of end-use applications. Therefore, the use of unpigmented resins in bottles is preferred to pigmented bottles.

LABELS PE or PP label stock is preferred to all other label materials. Metallized labels increase contamination and separation costs and should be avoided. The use of PVC labels is undesirable and should be avoided. Paper labels are undesirable and should be avoided as they can increase contamination in the plastic regrind due to fiber and adhesive carry-over through the reclamation process. Full bottle sleeves should be so designed that automatic sorting equipment can properly identify the resin used to make
the bottle.

**INKS & ADHESIVES** Inks must be chosen that do not bleed color when agitated in water. Label inks that bleed can discolor plastic regrind in the reclamation process, diminishing or eliminating its value for recycling. The use of label inks that bleed should be scrupulously avoided. *(The APR has developed a testing protocol to assist label manufacturers in evaluating whether label ink will bleed in conventional reclamation systems)*.

The use of “hot melt” adhesives is undesirable and should be avoided unless the adhesive readily separates from the plastic and does not cause problems in the reclaiming process. Label adhesives should be water soluble or dispersible at temperatures between 140 °F to 180 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the plastic regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided. *(The APR has developed a testing protocol for adhesive manufacturers to evaluate the impact of adhesive products in conventional reclamation systems)*. Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize bottle base resin yield and avoid contamination.

**LAYERS** Some bottle designs require the use of layers for specific product applications. The use of layers made from materials other than the base resin is undesirable and should be avoided, unless they are compatible with or easily separable from the base resin in conventional recycling systems.

**OTHER ATTACHMENTS** The use of any other attachments is discouraged, as they reduce base resin yield and increase separation costs. Other attachment may include handles, inserts and pour spouts, in addition to others that might be developed. The use of attachments should not be adhesively bonded to the bottle and must readily separate from the bottle in conventional reclamation systems. If attachments are added to a bottle, they should be made from the same material as the base resin or be otherwise compatible with the base resin in conventional reclamation systems. The use of attachments should be limited to the greatest extent possible.

**POSTCONSUMER CONTENT** The use of postconsumer content in bottles is encouraged, whenever possible.

**RESIN IDENTIFICATION CODE, RIC** The use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged. Meeting the APR Critical Guidance for a specific resin as a supplemental demonstration of proper RIC assignment.