The APR Design™ Guide for Plastics Recyclability

Introduction

The APR Design™ Guide for Plastics Recyclability has been prepared by the Association of Postconsumer Plastic Recyclers (the APR) as a service to the plastics 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. While the scope of today’s APR Design™ Guide includes plastic bottles, thermoformed containers, plastic bags, and films, those designing any other plastic items will find useful information impacting plastics recycling in this Guide. The Guide offers a valuable overview of how plastic package design impacts conventional plastics recycling systems and provides useful recommendations on how problems routinely encountered by plastics recyclers can be addressed through design changes that make plastic packaging compatible with current recycling systems.

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 articles discussed in this guide. Because new technological developments are always being made, this guide cannot anticipate how these new developments might impact plastic recycling. Thus, while the information in this guide is offered in good faith by the 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. The 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.


The complete Guide is given below. APR also offers an executive summary of the Guide.
About the 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 processing capacity in North America. Its membership includes independent recycling companies of all sizes as well as many other stakeholders throughout the recycling value chain including: brand owners, materials suppliers, packaging suppliers, equipment manufacturers and consulting/testing groups. APR strongly advocates the recycling of all postconsumer plastic and recommends the use of postconsumer plastics in new products, where possible.

APR strives to eliminate obstacles to plastic recycling with technical programs, recycling compatibility testing methods and guidelines. These initiatives have been produced in response to a need to provide information to the plastic industry on what elements of package design may or may not affect the recycling of that package in current systems.
# Table of Contents

- Introduction .......................................................... 1
- About the APR ............................................................ 2
- Background – Why is it important to recycle postconsumer plastics? .................................................. 4
- Background – APR’s Champions for Change™ Program ................................................................. 5
- Background – Assessing the recyclability of plastics ........................................................................ 7
- Overview of plastic packaging collection and sortation ................................................................. 9
- General plastic reclamation process ............................................................................................... 12
- Description of Terms used in the APR Guide .................................................................................. 16
- PET Bottles (Carbonated Beverage, Water, and Custom Bottles) ................................................. 17
- PET Thermoformed Packages .......................................................................................................... 22
- Natural HDPE Milk & Water Bottles (unpigmented homopolymer resin) .................................. 26
- Pigmented HDPE Laundry Detergent & Household Chemical Bottles (copolymer resin) ....... 29
- HDPE Film and Bags ....................................................................................................................... 33
- Polyethylene (PE) Thin Wall Containers ......................................................................................... 34
- Polyvinyl Chloride (PVC) Bottles .................................................................................................. 39
- LDPE Film and Bags ....................................................................................................................... 42
- LLDPE Film and Bags ..................................................................................................................... 43
- Polypropylene (PP) Bottles ............................................................................................................. 45
- Polypropylene (PP) Thin Wall Containers ...................................................................................... 48
- Bottles Made from Resins Other than PET, HDPE, or PP ......................................................... 52
- PS, PLA & PVC Thin Walled Packaging ......................................................................................... 54

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Why is it important to recycle postconsumer plastics?

For many, the act of placing plastic packaging in a recycling bin is the final step in the life of a package. What happens next? What benefit does this material bring to our world? These questions are answered by APR members every day because they know the recycling bin is just the beginning of an amazing and inspiring journey of transformation for plastics.

Postconsumer plastics are the feedstocks to advanced engineering processes that produce high value plastic resins for hundreds of end use applications. Carpet fiber, plastic lumber, beverage bottles, food trays, detergent packaging, office furniture, plastic piping and pallet strapping are some of the end use applications for postconsumer recycled plastics, or PCR for short. Instead of using newly made plastics, often referred to as virgin plastics, PCR plastics can be used to substitute, in whole or in part, for virgin plastics. As a result, fewer new plastic materials are needed for end use applications which reduces our consumption and dependence on fossil feedstocks, such as oil and natural gas, from which the majority of plastics are derived.

A detailed assessment has shown that recycled PET and HDPE have lower energy and greenhouse gas impacts than conventional virgin PET and HDPE. This means that using PCR plastics in place of virgin plastics reduces the environmental burdens of the plastic articles they are made into. These findings are based on the “Life Cycle Inventory of 100% Postconsumer HDPE and PET Recycled Resin from Postconsumer Containers and Packaging” prepared by Franklin Associates, A Division of Eastern Research Group, conducted for the Association of Postconsumer Plastic Recyclers (APR), the Plastics Division of the American Chemistry Council, Inc., the National Association for PET Container Resources (NAPCOR) and The PET Resin Association (PETRA). The life cycle inventory data for recycled PET and HDPE Franklin Associates developed can be accessed publically via the US LCI Database.

Packaging producers, brand companies and retailers can support the supply and quality of PCR plastics by ensuring their products are designed for recycling. Making use of this APR Design™ Guide is a great way to determine if packaging is compatible with commercial recycling processes. By designing for recycling, a competitive advantage in the marketplace may be gained by increased consumer appreciation and loyalty. For plastics recyclers, a well-designed package means yield losses are reduced, quality is routinely maintained, profitability is increased and reinvestment in state-of-the-art recycling equipment is enabled.

The general public can further contribute to plastics recycling by trying to recycle more and by ensuring that the articles placed in recycle bins will contribute positively to the production of PCR plastics. Cleaning and emptying packaging, crushing bottles, and then placing caps back
on the threads, keeping food waste and non-recyclable articles out of the bin, are important steps we can all take.

➢ APR’s Champions for Change™ Program

The APR Design™ Guide for Plastics Recycling can be used as a stand-alone document. But it is important to know that it is one of several components that comprise the APR’s Champions for Change™ Program. The APR created the Champions for Change™ Program to promote the recyclability of today’s plastic packaging as well as to support and recognize those innovators developing new packaging materials that are demonstrated by testing to be compatible with recycling. The APR Design™ Guide for Plastics Recycling is the foundation of the Champions for Change Program. Other components include testing and evaluation methods, Guidance Documents, APR Bulletins and APR Recognition for innovators. These other components are summarized below and details can be found on the APR’s web site.

SCREENING TEST PROCEDURES
The APR publishes and maintains a variety of test methods that innovators can use to gage the impact of an innovation on recycling. Screening tests typically evaluate a narrow aspect of an innovation or a package component on recycling. For example, a screening test might evaluate how well a closure or label floats in water, or how much color develops in PET from an extrusion or injection molding heat history.

Many of these tests use equipment that is commonly available in a technical development laboratory and can be employed in a variety of laboratories. Some of the test methods employ specialized equipment that is not generally available and may be best conducted at a specialized laboratory experienced in conducting recycle tests.

BENCHMARK TEST PROCEDURES
This is a recently developed category of laboratory tests that we employ for materials or technologies where we want to assess recycle performance of an innovation to the best of our ability, but where experience tells us we may not know all the variables or conditions that need to be evaluated. While these are comprehensive recycling evaluations, we do not have the experience to know they capture all the important aspects impacting the product area.

IN-PLANT PRODUCTION SCALE TESTS
With some new technologies laboratory tests may not be able to predict recycling performance, or we do not have established laboratory tests available. It may be desirable to evaluate an innovation under regular production scale conditions. APR members are often willing to make their facilities available for such evaluations.
CRITICAL GUIDANCE DOCUMENTS
These Documents provide a comprehensive laboratory scale recycling testing plan and test result evaluation criteria to assess the impact of an innovation on key aspects of recycling PET or HDPE resins and packaging. Critical Guidance is available today for only PET and HDPE because these are the two resins where there is ample industry experience to allow us to know how to test and how to evaluate test results in the laboratory to evaluate plant scale performance with confidence.

The testing can start with either a new resin, or from bottles made with a new additive or packaging component innovation. Bottles are recycled and processed to pelletized resin. Injection molded plaques are made to assess the impact of the innovation on color of the plaques.

Because there is no single standard recycling process, the tests and measurements made are selected to be meaningful to most stakeholders in the recycling industry. The purpose of these tests is to confirm that an innovation is fully compatible with the appropriate plastic recycling stream. The testing plan purposely uses a high level of the innovation in each assessment to reveal potential for a negative impact.

APPLICATION GUIDANCE DOCUMENTS
These Documents provide a comprehensive recycling test and test result evaluation criteria for recycling a complete package innovation back into a finished article, not simply a molded plaque as in Critical Guidance. Applications Guidance for HDPE calls for innovations to be recycled back into new HDPE bottles. For PET, Applications Guidance provides for recycling an innovation back into new bottles, sheet, fibers, or strapping. The purpose is to test specific shelf-ready packages for technical compatibility with recycling, including all components of the package.

APR GUIDANCE RECOGNITION
The APR wants to recognize those innovators that have developed new products and technology that are compatible with recycling. For those who have completed Critical or Applications Guidance, innovators can provide data to an APR review team. APR can recognize those who have met both the criteria of the APR Design™ Guide, as well as the strictest criteria identified in the Guidance Documents. This is the most common form of APR recognition.
For innovations where Critical or Applications Guidance Documents do not exist, the APR may be able to develop a special evaluation program in co-operation with an innovator and recognize the innovation for meeting mutually agreed criteria that demonstrate that the innovation is compatible with the recycling stream. We anticipate that this special program will use a combination of the most rigorous laboratory test procedures available in combination with in-plant test evaluations.

**APR INNOVATION BULLETINS**

From time to time there are new product technologies or innovations being introduced into the plastics industry and it is in the interest of both the innovator and the APR membership to understand the potential impact of that innovation on recycling. But because these products are new, or might involve a resin other than HDPE or PET, there may not be an agreed upon method to evaluate the compatibility of the innovation with recycling.

For those who conduct Benchmark Testing, and/or other plant scale evaluations, the APR offers innovators the opportunity to submit data and testimonials to an APR review team and allow the innovator to post an Innovation Bulletin on the APR web site. This Bulletin describes the technology and the available testing results. This is an opportunity for stakeholders to learn about a new technology and make informed decisions about its use with the best available testing information.

- **Background – Assessing the recyclability of plastics**

  The APR has identified three measures of whether a plastic article is recyclable:

  1. Consumers need access to a means of collection of postconsumer plastics, typically through either curb side pick-up or local drop-off sites.
  2. The article must be economically feasible to recycle.
  3. The article must be technically compatible with recycling processes used today.

  These three measures are discussed below.

**ACCESS**

For an article to be recyclable, the end user must have access to a collection site for that material. So while many consumers have access to curb side or local drop-offs for plastics such as HDPE or PET, other plastics may not yet be collected today in a given community. Or, perhaps PP bottles are accepted for recycling, but large toys or bins made from PP are not.
ECONOMIC FEASABILITY
An item must be readily recognized by individuals and auto-sortation equipment at sufficient quantity in the mixed curb side stream of materials that the item can be sorted, be combined with other similar plastic materials and processed economically. As a practical matter, this means that as a bare minimum, truckload quantities of baled materials can be collected on a regular and predictable basis. Experience with HDPE, PET and PP show that the United States market must reach about 300 million pounds of recognizable material per year to have routine economic potential for postconsumer recycling.

TECHNICALLY COMPATIBLE
A minimum measure of technical compatibility is meeting the preferred package requirements outlined in the APR Design™ Guide for Plastics Recyclability which are presented in sections of this document below.

The best measure is that when an article is blended with its family of plastics, the inclusion of the article at 50% into the typical stream of the family of plastics must not devalue the typical stream. This level of technical compatibility can be assessed by employing APR Guidance Documents.
Overview of plastic packaging collection and sortation

COLLECTION
The majority of plastic bottles and containers collected for recycling today come from curbside collection programs where individual homeowners conduct some degree of separation of designated recyclable materials from their trash and place them out for collection in special bins or bags. Some collection programs may separate recyclable items from collected trash. These recyclables may include containers such as glass and plastic bottles, other plastic containers, plastic bags and films, 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 most often taken to a materials recovery facility (MRF) for further separation and processing. The output of the MRF is bales sorted by type of plastic that are sold to those companies who actually recycle or reclaim a given type of plastic. Bales of plastic bottles weigh on the order of 1,000 to 1,300 pounds and are shipped by the truck load. The schematic below shows how household recyclables may be collected from the curbside, sorted and sold, and processed to useful new items of commerce.
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 or container redemption value 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;

These source separated materials are then collected and sent to a MRF, or in some cases directly to a specific material reclaimer.
Plastic bags and films from householders are often collected by drop-off at specified retailers or other locations. Plastic films used as secondary and tertiary packaging for industrial or commercial use are often accumulated for recycling at distribution locations.

**Sorting**
Sorting of whole bottles by resin type is essential to effective plastic bottle recycling and generally takes place at the MRF 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 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 (SPI/ASTM code). 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. Sorting personnel do examine unfamiliar bottles for the resin identification code.

**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. Many MRF’s currently accept all rigid plastic packaging for recycling into mixed resin products like plastic lumber or sorted into separate resin categories. Some MRF’s only accept specific resins and containers to maximize the value of the specific categories of materials collected for recycling.

This APR Guide 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. The Guide also discusses injection molded thin walled containers, including PET thermoform trays, and films and bags.

➢ General plastic reclamation process

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, Air Separation, Washing, Sink-Float, Rinsing/Drying and Melt Finishing. Reclaimers also Sort incoming material.

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, PET soda bottle vs. a HDPE container.
Granulation and Air Separation
Granulation and air separation are frequently the first steps in the reclamation process. Following sorting by resin type, whole bottles are ground by sharp rotating metal blades 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 and rinsing
Bottles may be pre-washed before sorting and granulation at some reclaimers. All reclaimers will wash the ground flake. The washing may be done at ambient or elevated temperatures and usually includes the addition of detergents 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. Washed flake is rinsed.

Float-Sink 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) by using water as a flotation media. 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.

### Density Range of Key Plastics and Closure Materials

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>DENSITY (grams/cubic centimeter)</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>EPS</td>
<td>Variable, usually below 0.80</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2.70</td>
</tr>
</tbody>
</table>

**Rinsing/Drying**

Rinsing is done to remove residual dirt and detergent from plastic regrind after it is washed and sink/float separated. Sink/float separation is often followed by drying and a second air separation step to remove lighter materials that have been liberated in the wash system. Flake "polishing" with a second air separation step automatically sorts out low concentration particle contamination. The material is dried to a level necessary for remanufacturing applications or for further processing stages.

**Melt Finishing**

An additional processing stage that may take place at a reclaimer is called melt finishing. In this step, clean ground flake is passed through an extruder to melt the resin, filter particulates from the melt, and to create pellets of plastic from the flake.

Melt filtering removes non-melting, particulate contaminants in plastic regrind that may remain after sorting, washing and separation stages. These particulate contaminants might include metal, wood, or paper particles. Melt filtration occurs inside the extruder, where the plastic regrind is melted and filtered through one or more metal filtering 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.
End Markets
Post consumer resins 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.

PCR can be used in a wide variety of demanding end use applications. Some applications are served by blending PCR with virgin resin to make new molded articles. Many plastic molding applications can be served by employing high quality PCR at 100 per cent of the article. Plastic reclaimers strive to produce the highest quality PCR to serve the highest value recycling applications and to allow use at the highest possible PCR contents in new products.

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 as well as to support sustainability initiatives of those specifying and buying plastic articles. Better bottle design that incorporate APR Design™ 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.
Identification of plastic resins included in the APR Guide

Plastic resin names

EPS – Expanded polystyrene
EVA - Ethylene vinyl acetate
EVOH - Ethylene vinyl alcohol
HDPE – High density polyethylene, (Resin Identification Code) RIC 2
LDPE - Low density polyethylene, RIC 4
LLDPE - Linear low density polyethylene
MDPE - Medium density polyethylene
OPP - Oriented polypropylene
PCR - Postconsumer resin
PET - Polyethylene Terephthalate, RIC 1
PLA – Polylactic acid
PP – Polypropylene, RIC 5
PS – Polystyrene, RIC 6
PVC - Polyvinyl chloride, RIC 3
PET (Polyethylene Terephthalate, Resin Identification Code #1)

Highlights
- Non-PET package parts – labels, closures, attachments – should float in water
- Confirm adhesives used with pressure sensitive labels wash off cleanly
- Avoid paper labels and inks that contaminate wash/rinse water
- Sleeve labels should be designed to allow auto-sorption for resin and color
- Be sure additions to PET plastic do not discolor or haze the PET
- Clear PET has more recycle value than colored and opaque PET

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™ 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, and 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. Label materials should not delaminate in the reclamer’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
Direct printing other than date coding, either for product labeling or decoration, contaminates recycled PET in conventional reclamation systems and should be avoided. Experience has shown that 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.

Anticipating innovation in direct printing technology, direct printing on a specific bottle can be
acceptable when APR Guidance Tests are used to demonstrate the direct printing has no impact on recycling. The tests to employ are both the Critical Guidance Test for PET Bottles as well as the Applications Guidance Test for PET Bottle to Bottle Recycling where results meet the strictest guidance called for in the test methods.

**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™ Program invites consumer product, plastic bottle and bottle component manufacturers to work with the APR protocols 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.)** Testing should be conducted per APR’s Degradable Additives and PET Recycling Technical Compatibility Testing Guidance.

**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.
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**
Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.
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™ Program invites consumer product, plastic bottle and bottle component manufacturers to work with the APR protocols 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™ Program invites consumer product, plastic bottle and bottle component manufacturers to work with the APR protocols 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. Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.

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.

➢ **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

HDPE Packaging

PlasticsRecycling.org
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™ Program invites consumer product, plastic bottle, and bottle component manufacturers to work with the APR protocols 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™ Program invites consumer product, plastic bottle and bottle component manufacturers to work with the APR protocols 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. Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.

**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 use 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
Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.

**HDPE Film and Bags**

Recycling of HDPE films and bags has significant differences from recycling rigid HDPE. The film and bag recycling often does not include water washing so the density of the films and bags need not necessarily be less than 1.0 gram per cubic centimeter. However, floating films and bags are good which means added fillers should be kept to what is functionally needed. The ability to float is encouraged for fully decorated films including colors and printing.

**COLOR**
In general, HDPE bags are pigmented and that is fully acceptable, particularly white bags. HDPE films have greater value to recyclers if unpigmented although some recyclers accept pigmented films.

**PRINTING and DECORATION**
Printing on HDPE bags is unimportant to recycling. Printing on HDPE films is acceptable. The inks used in direct printing may bleed ink into wash water. Testing should be conducted to confirm no adverse impact on the reclaiming process.

**LABELS**
HDPE bags usually do not include labels and are best with no labels, although labels may be attached. Any label used should include as little adhesive as possible. Neither paper labels nor metalized labels are encouraged for HDPE bags. Polypropylene or polyethylene labels are suggested for HDPE bags when a label is needed. Use of adhesives for bags should be kept to a minimum. Although HDPE films usually do not include labels, if needed, labels may be attached. Polypropylene or polyethylene labels are preferred for HDPE films. Paper labels on HDPE films are generally acceptable.

**LAYERS and BLENDS**
HDPE bags and films are best if made of a single layer. Multilayer HDPE bags should be avoided if possible. Layers of acrylic should be discouraged and layers of PVDC must be avoided. HDPE bags and films are expected to be blends of HDPE and LLDPE and
sometimes LDPE, not non-polyethylene polymers. Such blends of polyethylene resins are acceptable, although LLDPE is the more expected blending material. Aluminized or metalized layers on HDPE bags and films are not encouraged.

**ADDITIVES**

Unlike rigid HDPE packaging, HDPE bags and films may include mineral fillers such as calcium carbonate or talc. It is desirable that mineral-filled HDPE films and bags can float in water. Slip additives are acceptable for both HDPE bags and films. Silicone coatings are not encouraged for HDPE films. Antistats are acceptable for both HDPE bags and films. Conductive carbon on HDPE films should be minimized.

Degradable additives must not be used without an evaluation confirming that their expected use will not impair the full service life and properties, including durability, for the next use of the recycled HDPE bags and films including use in plastic lumber. **Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.**

**POSTCONSUMER CONTENT**

The use of postconsumer HDPE in bags and films is encouraged, whenever possible.

**RESIN IDENTIFICATION CODE, RIC**

Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.

- **Polyethylene (HDPE) Thin Wall Containers**

For purposes of this design guidance document, thin walled packaging, also known as thin walled containers, are rigid plastic packaging with a wall thickness less than 0.08 inches and a volume of less than 2 gallons. Thin walled containers fall primarily into two groups – thermoformed/vacuum formed and injection molded. Examples of thin walled containers include dairy tubs, bakery packaging, sandwich packs, yogurt cups, drink cups, ice cream and margarine tubs, hinged containers, small buckets, small crates and baskets, and microwave and freezer containers. Flexible film, pouches or squeeze tubes are not included in this design guidance document.

Such thin wall packaging is most often made with HDPE, but can also be made from other grades of polyethylene such as low density polyethylene, LDPE. In this guidance, we use the general composition of PE so that guidance can apply to any grade of PE resin.

**ATTACHMENTS**

The basic design for recycling guideline to consider when making material choices for any attachment to a container is to consider its general compatibility with the base resin (PE) 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. PE 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 PE in the reclamation process. Materials with a density greater than 1.0 will sink in these systems and can be separated easily from the PE.

Attachments made entirely of PE are preferred, as non-polyethylene 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-PE attachments should not be adhesively bonded to the container and should readily separate from the container in conventional PE reclamation systems. If attachments are added to a container, 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 PE in conventional separation systems or, 2) compatible materials such as pigmented, or preferably non-pigmented PE. The use of PP attachments, if necessary, should be employed at the lowest possible level of total container weight to minimize the presence of PP in PE that can degrade the physical properties of postconsumer PE. High percentages can contaminate the PE for many recycling applications, as these materials are difficult to separate from PE in conventional systems. If pour spouts are added to a container, they should be designed to leave no product residue and allow for complete removal of product contents when the container 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 60°C to 80°C in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PE 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 PE yield and avoid contamination. Silicone and rubber closure parts are not acceptable given the technically significant challenges they present to the process of recycling and the usefulness of the recycled plastic.

COLOR
The use of non-pigmented PE containers is generally preferred to pigmented containers as the non-pigmented containers have a greater number of potential applications. A light or translucent color is acceptable.

LIDS & CLOSURES
Plastic lids, lid stock or 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 container after the closure is removed. The use of lidding and closures that are non-pigmented or the same color as the container is desirable, if practical. The use of PVC for closures or closure liners is not acceptable. 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 and rubber closure parts are not acceptable given the significant technical problems in the process of recycling and to the utility 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 container. 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 container, 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 container, leaving no remains on the container. Shrink sleeves are preferred to adhered labels. Shrink sleeves made from PE or PP are preferred. The use of PVC sleeves or safety seals are not acceptable. Foil safety seals that leave foil or remnants or attaching adhesive on the PE containers are not acceptable.

**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 PE due to fiber and adhesive carry-over through the reclamation process. Labels should be as minimal as possible and not exceed 60% of the package coverage.

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

Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PE yield and avoid contamination. 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 60°C and 80°C in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PE regrind and embed unwanted contaminants. Residual adhesives must not scorch, discolor, haze or form black specks at plastic processing conditions. 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).

**DIRECT PRINTING/DECORATION**
Presently, all direct printing other than date coding, either for product labeling or decoration, contaminates recycled PE in conventional reclamation systems. The inks used in direct printing should not bleed ink or otherwise discolor the PE during processing, or introduce incompatible contaminants. In either case, the value of the PE for recycling is diminished or eliminated. Ink coverage should be minimized.

**LAYERS**
Some PE container designs require the use of layers for specific product applications. The use of non-PE layers is undesirable and should be avoided, unless they are compatible with or easily separable from PE in conventional recycling systems.

Current PE 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 PE yield and reduce potential contamination and separation costs. (The APR’s Champions for Change™ Testing Program invites consumer product, plastic container and container component manufacturers to work with the APR protocols to determine whether new modifications to a regularly recycled plastic container 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, the use of oxo-degradable and/or biodegradable additives in PE may result in shortening the useful life of containers of which they are a part and therefore affect the ability of such containers 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. Overall, oxo-degradable and biodegradable 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 recycling and durability, for the next use of the recycled thin walled container. Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.

Any mineral filler must NOT raise the package specific gravity above 0.98 gm/cc.

**POSTCONSUMER CONTENT**
The use of post consumer PE in containers is encouraged, whenever possible.

**RESIN IDENTIFICATION CODE, RIC**

HDPE Packaging
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 is a supplemental demonstration of proper RIC assignment.
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
Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.
**LDPE (Low Density Polyethylene, Resin Identification Code 4) LLDPE (Linear Low Density Polyethylene)**

**Highlights**
- Be sure non-polyolefin parts sink in water

> **LDPE Film and Bags**

LDPE film and bag recycling often does not include water washing so the density of the films and bags need not necessarily be less than 1.0 gram per cubic centimeter. However, floating films and bags are good which means added fillers should be kept to what is functionally needed. The ability to float is encouraged for fully decorated films including colors and printing.

**COLOR**
Uncolored LDPE bags and films are preferred, although pigmented LDPE bags are usually acceptable.

**PRINTING and DECORATION**
Printing on LDPE bags is generally unimportant to recycling, but when done should be kept to a minimum. Printing on LDPE films is acceptable. The inks used in direct printing may bleed ink into wash water. Testing should be conducted to confirm no adverse impact on the reclaiming process.

**LABELS**
LDPE bags may include labels, but are best with no labels. Any label used should include as little adhesive as possible. Neither paper labels nor metalized labels are encouraged for LDPE bags. Polypropylene or polyethylene labels, preferably polyethylene, are preferred for LDPE bags when a label is needed. Labels on LDPE films are expected. Polypropylene or polyethylene labels are preferred for LDPE films. Paper labels on LDPE films are generally acceptable.

**LAYERS and BLENDS**
LDPE bags and films are preferred if made of a single layer, although multilayer constructions are often acceptable. Layers of acrylic are discouraged and layers of PVDC or Barex® must be avoided. LDPE bags and films are expected to be blends of LDPE, HDPE, and LLDPE, not non-polyethylene polymers unless compatibility is shown. Aluminized or metalized layers on LDPE bags are not encouraged.
ADDITIVES
LDPE bags and films may include mineral fillers such as calcium carbonate or talc. It is desirable that mineral-filled LDPE films and bags can float in water. Slip additives are acceptable for both LDPE bags and films. Silicone coatings are not encouraged for LDPE films. Antistats are acceptable for both LDPE bags and films, although compatibility needs to be confirmed.

Degradable additives must not be used without an evaluation confirming that their expected use will not impair the full service life and properties, including durability, for the next use of the recycled LDPE bags and films including use in plastic lumber. Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.

POSTCONSUMER CONTENT
The use of postconsumer LDPE in bags and films is encouraged, whenever possible.

RESIN IDENTIFICATION CODE, RIC
Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.

LLDPE Film and Bags
LLDPE film and bag recycling often does not include water washing so the density of the films and bags need not necessarily be less than 1.0 gram per cubic centimeter. However, floating films and bags are beneficial which means added fillers should be kept to what is functionally needed.

COLOR
Uncolored LLDPE bags and films are preferred, although pigmented LLDPE bags are usually acceptable.

PRINTING and DECORATION
Printing on LLDPE bags is generally unimportant to recycling, but when done should be kept to a minimum. Printing on LLDPE films is acceptable. The inks used in direct printing may bleed ink into wash water. Testing should be conducted to confirm no adverse impact on the reclaiming process.

LABELS
LLDPE bags may include labels, but are best with no labels. Any label used should include as little adhesive as possible. Neither paper labels nor metalized labels are encouraged for
LLDPE bags. Polypropylene or polyethylene labels, preferably polyethylene, are preferred for LLDPE bags when a label is needed. LLDPE films are best without labels although labels may happen. Polypropylene or polyethylene labels are preferred for LLDPE films. Paper labels on LDPE films are generally accepted. Metallized labels are not encouraged for LLDPE film.

LAYERS and BLENDS
LLDPE bags and films are preferred if made of a single layer, although multilayer constructions are often acceptable. Layers of acrylic are discouraged and layers of PVDC must be avoided. LLDPE bags are best if not including LDPE. LLDPE films are expected to be blends of LDPE, HDPE, and LLDPE.

ADDITIVES
Slip additives are acceptable for both LLDPE bags and films. Silicone coatings are not encouraged for LLDPE films. Antistats are acceptable for both LLDPE bags and films, although compatibility needs to be confirmed. Use of flame retardants should be minimized for LLDPE film.

Degradable additives must not be used without an evaluation confirming that their expected use will not impair the full service life and properties, including durability, for the next use of the recycled LLDPE bags and films including use in plastic lumber. Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.

POSTCONSUMER CONTENT
The use of postconsumer LLDPE in bags and films is encouraged, whenever possible.

RESIN IDENTIFICATION CODE, RIC
Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.
PlasticsRecycling.org

PP (Polypropylene, Resin Identification Code 5)

Highlights
- Be sure non-polyolefin parts sink in water
- Be sure PP items with mineral filler float in water

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™ Program invites consumer product, plastic bottle and bottle component manufacturers to work with the APR protocols 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™ Program invites consumer product, plastic bottle and bottle component manufacturers to work with the APR protocols 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. Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.)

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 use 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.

➢ Polypropylene (PP) Thin Wall Containers

For purposes of this design guidance document, thin walled packaging, also known as thin walled containers, are rigid plastic packaging with a wall thickness less than 0.08 inches and a volume of less than 2 gallons. Thin walled containers fall primarily into two groups – thermoformed/vacuum formed and injection molded. Examples of thin walled containers include dairy tubes, bakery packaging, sandwich packs, yogurt cups, drink cups, ice cream and margarine tubs, hinged containers, small buckets, small crates and baskets, and microwave and freezer containers. Flexible film, pouches or squeeze tubes are not included in this design guidance document.

ATTACHMENTS
The basic design for recycling guideline to consider when making material choices for any attachment to a container 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 PP.

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 container and should readily separate from the container in conventional PP reclamation systems. If attachments are added to a container, 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 non-pigmented PP. The use of HDPE or LDPE attachments, if necessary, should be employed at the lowest possible level of total container weight to minimize the presence of PE in PP. High 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 container, they should be designed to leave no product residue and allow for complete removal of product contents when the container 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 60°C to 80°C 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 and rubber closure parts are not acceptable given the technically significant challenges they present to the process of recycling and the usefulness of the recycled plastic.

COLOR
The use of non-pigmented PP containers is generally preferred to pigmented containers as the non-pigmented containers have a greater number of potential applications. A light or translucent color is acceptable.

LIDS & CLOSURES
Plastic lids, lid stock or 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 container after the closure is removed. The use of lidding and closures that are non-pigmented or the same color as the container is desirable, if practical. The use of PVC for closures or closure liners is not acceptable. 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 and rubber closure
parts are not acceptable given the significant technical problems in the process of recycling and to the utility 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 container. 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 container, 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 container, leaving no remains on the container. Shrink sleeves are preferred to adhered labels. Shrink sleeves made from PE or PP are preferred. The use of PVC sleeves or safety seals are not acceptable. Foil safety seals that leave foil or remnants or attaching adhesive on the PP containers are not acceptable.

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. Labels should be as minimal as possible and not exceed 60% of the package coverage.

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 APR has developed a testing protocol to assist label manufacturers in evaluating whether label ink will bleed in conventional PP reclamation systems).

Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PP yield and avoid contamination. 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 60°C and 80°C 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. Residual adhesives must not scorch, discolor, haze or form black specks at plastic processing conditions. 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).

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 should not 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. Ink coverage should be minimized.

LAYERS
Some PP container 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™ Testing Program invites consumer product, plastic container and container component manufacturers to work with the APR protocols to determine whether new modifications to a regularly recycled plastic container will impact conventional recycling systems prior to introducing the modification. The APR Guidance Documents should be the basis for test program design)

ADDITIONS
Based on public product performance claims, the use of oxo-degradable and/or biodegradable additives in PP may result in shortening the useful life of containers of which they are a part and therefore affect the ability of such containers 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. Overall, oxo-degradable and biodegradable 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 recycling and durability, for the next use of the recycled thin walled container. Testing should be conducted per APR’s Degradable Additives and Polyethylene and Polypropylene Recycling Technical Compatibility Testing Guidance.

Any mineral filler must NOT raise the package specific gravity above 0.98 gm/cc.

POSTCONSUMER CONTENT
The use of post consumer PP in containers 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.
PS and EPS (Polystyrene, Resin Identification Code 6)

Bottles made of resins other than PET, HDPE, PVC, LDPE, PP, or PS (Other, Resin Identification Code 7)

PS, PLA, and PVC Thin Walled Packaging listed below (Resin Identification Code 6, 7, and 3)

- **Items Made of Polystyrene**
  See below

- **Bottles Made from Resins Other than PET, HDPE, or PP (which are the bottle 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™ Program invites consumer product, plastic bottle and bottle component manufacturers to work with the APR protocols 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
Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.

➢ PS, PLA & PVC Thin Walled Packaging

For purposes of this design guidance document, thin walled packaging, also known as thin walled containers, are rigid plastic packaging with a wall thickness less than 0.08 inches and a volume of less than 2 gallons. Thin walled containers fall primarily into two groups – thermoformed/vacuum formed and injection molded. Examples of thin walled containers include dairy tubes, bakery packaging, sandwich packs, yogurt cups, drink cups, ice cream and margarine tubs, hinged containers, small buckets, small crates and baskets, and microwave and freezer containers. Foamed products, flexible film, pouches or squeeze tubes are not included in this design guidance document.

The basic design guideline to consider when making material choices for any attachment to the packaging is to consider its general compatibility with the base resin (PS, PLA or PVC) and/or the removal efficiency in conventional water-based separation systems that separate plastics by density. Attachments may include closures, closure liners, inserts, labels, sleeves, safety seals, coatings, and layers. PS, PLA and PVC all have densities 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 PS, PLA or 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 PS, PLA or PVC thin walled packaging.

It should be noted that the design for recyclability guidance for PS, PLA and PVC as represented in this document are based on a much more limited number of survey responses as was received for other resins. As more experience is gained with the design and recycling of PS, PLA and PVC more definitive guidance will be incorporated into this document.

COLOR
Both PS and PLA have a wide tolerance for color though the ideal color is natural or clear. Other colors/hues in these resins that are acceptable or encouraged include light transparent or translucent colors, a white opaque color, and light hue or dark hue opaque colors. With regard to PVC the tolerance for different colors/hues need further research and testing. For PS and PLA, an inner layer of plastic with a different color than the skin is acceptable although a black inner liner is discouraged.

Black and very dark colors are undesirable in PS, PLA and PVC due to the difficulty of sorting with near-infrared (NIR) optical sortation technology. The cameras used in these systems incorporate NIR, in which the near-infrared spectrum of light reflected by the plastics is evaluated. Each type of plastic has its own characteristic spectrum that serves to identify the material. Black plastics, however, do not reflect the radiation so no spectrum can be recognized and the materials cannot be sorted.

CLOSURES & CLOSURE LINERS
For PS and PVC containers made with closures from HDPE, LDPE, or PP are encouraged. The use of closures made of the same material as the container is desirable when the closure is the same color as the container. The use of aluminum rigid or foil closures is undesirable for PS, PLA, and PVC containers as they are more difficult and more costly to remove. If a metal foil closure is used, it must not leave foil or adhesive residue on the plastic container.

Due to the likelihood of removable closures such as lids becoming separated from thin-walled containers, lids should oppositely sink or float in relationship to the characteristic of the base materials. In the case of PS, PLA and PVC this means lids should be made of PP or another floatable material.

SLEEVES & SAFETY SEALS
Tamper resistance may be required in specific product applications. In general, the use of tamper-evident seals is discouraged if they are not of the same resin type as the base packaging or are not completely removed by the consumer. PVC tamper-evident seals that remain with the container are not acceptable on PS or PLA thin-walled packaging as they cause problems with the melting process. As for PVC tamper-evident seals on PVC packaging, they may be acceptable in some applications but not others. The use of OPS tamper-evident seals on PS thin walled packaging should be minimized as much as possible.
Safety seals and sleeves, if not of the same resin type as the thin walled packaging, can act as contaminants if they do not completely detach from the packaging or are not easily removed in conventional separation systems. As a result, if sleeves or safety seals of a different resin type are used on PS, PLA and PVC packaging, they should be designed to completely detach from the container, leaving no remains on the container. If sleeves are used, they should be as minimal as possible and should not exceed 60% of the package coverage. Full coverage sleeves (100%) are not acceptable.

**LABELS**
As noted previously, PS, PLA and PVC all have densities greater than 1.0 making them sink in conventional water-based separation systems that separate plastics by density. In order to remove labels effectively in these systems, labels made from the base resins or from materials with densities less than 1.0 are encouraged.

In-mold labels that detach in hot caustic water are encouraged for PS. For PS, PLA and PVC thin walled packaging, paper labels are acceptable but should be used cautiously as in conventional water-based separation systems fiber and adhesive can be carried over through the reclamation process. PP and PE labels are also acceptable on PS, PLA and PVC thin walled packaging. In most cases, a label made from the same resin type as the container is preferable.

Metalized labels are not acceptable on PS and PLA containers and can increase contamination and separation costs. For these reasons they should be avoided. Similarly, the use of PVC labels is undesirable and should be avoided for PS and PLA containers.

**INKS & DIRECT PRINTING**
For PS, PLA and PVC, inks that do not bleed color when agitated in water are strongly encouraged. Direct printing on PS and PVC thin walled packaging should be minimized as much as possible. For PS and PVC packaging, ink coverage of less than 30% of the labels used is encouraged. Ink coverage on labels used on PLA thin walled packaging does not matter so long as wash water is not stained. Spalling ink particles can be problematic on PS and PLA packaging. On PS packaging the ink must not spall or come off as sinking particles. PVC may have a higher tolerance for spalling ink particles.

**ADHESIVES**
Adhesive amounts used to attach the label to the packaging should be minimal for PS, PLA and PVC packaging. When used, label adhesives should be water soluble. They should be dispersible at temperatures greater than 176°F in order to be successfully removed in conventional washing and separation system. This is a conservative figure but one that should be acceptable for most PS and PLA thin walled package and label design.
Residual adhesives on PS, PLA and PVC must not scorch, discolor, haze, or form black specs at plastic processing conditions. As noted previously, any metal foil closure must not leave adhesive residue on the container.

**COATINGS AND LAYERS**

For PS, coatings and layers are discouraged unless they are compatible with, or easily separable in, conventional recycling systems. PS containers may also have a low tolerance for PVDC layers and at this time such layers are discouraged. However, further research and testing on this topic may be warranted.

As for PLA and PVC, coatings and layers are somewhat more tolerable but, as a rule of thumb, they should be avoided unless it is compatible with the PLA or PVC substrate, or can be separated from the base materials through conventional recycling systems. As with PS, PLA has a low tolerance for PVDC layers due to thermal degradation issues and their use should be discouraged. Further research and testing of PVDC layers may be warranted here, as well.

**ADDITIVES**

Of the three resin types covered under this guidance document, PS is the most restrictive on the use of additives. De-nesting agents, as an example, are not encouraged and should be avoided when possible. If de-nesting agents are used, their use should be in minimal amounts. The same holds true for anti-slip agents. In some instances slip additives are not a significant issue but can be application and converter specific. Further discussions with the processor and converter are encouraged to minimize any problems specific to the use of slip additives. Caution should be used when adding anti-blocking agents and typically they are not encouraged and should not be used. Though not a problem with some recyclers, anti-stat agents should not be encouraged and if used should be in minimal amounts. As for lubricants and process aids, for PS they are generally not a significant problem.

For PLA and PVC, de-nesting agents are typically not a problem but should be used in minimal amounts. The same holds true for anti-slip agents. Slip additives, anti-blocking agents and anti-stat agents are generally not an issue when it comes to the recyclability of PLA and PVC. Lubricants and process aids may or may not be hindrances that disrupt recycling of PLA and PVC. For this reason, consultation with the recycler is recommended prior to using lubricants and process aids.

Based on public product performance claims, the use of oxo-degradable and biodegradable additives in PS, PLA and PVC result in shortening the useful life of containers of which they are a part and therefore affect the ability of such containers to be recycled. Even as an additive to PLA, which is both a compostable and recyclable resin, depending on the application, the use of such additives can impact the recyclability and compostability of the product. Overall, oxo-degradable and biodegradable 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 recycling and durability, for the next use of the recycled thin walled
Functional mineral fillers are often used for pigmentation. As previously noted, due to the difficulty NIR optical sorters have with detecting dark colors such as black, functional fillers which impart a black or brown pigment to a base container or its cover are discouraged. Ideally, a base container and its lid should both be clear or pigmented the same color.

The use of mineral fillers is an unresolved issue for many resin types and further study of this issue is advised.

**OTHER ATTACHMENTS**

Other attachments made from the respective base resins (PS, PLA, or PVC) are preferred to all others as the use of attachments made from other resins will reduce yield and increase separation costs in the recovery of all three resins. Other attachments may include handles, inserts and pour spouts, in addition to others that might be developed. Non-PS, PLA or PVC attachments should not be adhesively bonded to the thin walled package and must readily separate from the container in conventional separation systems.

If non-base resin attachments are added to a thin walled package, they should be made from materials with a density less than 1.0 so that they easily separate from PS, PLA or PVC in conventional separation systems. The use 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 temperatures above 176 °F in order to be removed in conventional washing and separation systems. If adhesives are not removed efficiently, they may disperse on the PS, PLA and PVC regrind and embed unwanted contaminants. The use of other adhesive types is discouraged and should be avoided.

Adhesive usage and surface area covered should be minimized to the greatest extent possible to maximize PS, PLA and PVC yield and avoid contamination. The use of melt blends and inseparable mixes of different plastics should be avoided unless the blend is shown compatible with the generic resin with which an item of the blend or mixture would be collected. Layers of different plastics should be confirmed to be compatible. Both of these last two items are critical criteria for PS and though less so for PLA and PVC, are nonetheless important considerations.

**POSTCONSUMER CONTENT**

The use of postconsumer content in a variety of PS, PLA and PVC applications is encouraged, whenever possible.

**RESIN IDENTIFICATION CODE, RIC**

Use the correct Resin Identification Code symbol of the proper size as detailed in ASTM D7611 is encouraged.