The Association of Plastic Recyclers

The APR Design® Guide for Plastics Recyclability is the most comprehensive resource outlining the plastics recycling industry's recommendations in the marketplace today. The content is regularly updated to ensure APR's Recyclability Categories represent today's North American plastics recycling infrastructure. Although it is designed as an online resource, with links to all relevant information, a PDF of the complete document can be downloaded as well.

The APR Design® Guide specifically addresses plastic packaging, but the principles can be applied to all potentially recycled plastic items.

APR encourages package designers to utilize The APR Critical Guidance and Responsible Innovation programs, as well as the APR Design® Guide to create the most recyclable packaging. Assistance is available through APR or one of the APR member, independent laboratories found in the member directory.

The intended audience for the APR Design® Guide for Plastics Recyclability is the package design engineer for use in designing packaging that complies with the capabilities of the recycling infrastructure. Before accessing the APR Design® Guide for Plastics Recyclability the user should thoroughly understand the fundamentals of its concept as described in the scope, definition of recyclability and recyclability categories outlined below.

SCOPE

This guide covers plastic items entering the postconsumer collection and recycling systems most widely used in industry today. Collection methods include single stream and dual stream MRF's, deposit container systems, mixed waste facilities, and grocery store rigid plastic and film collection systems. The impact of package design on automated sortation process steps employed in a single stream MRF, as well as high volume recycling processes is of primary consideration.

Items recovered in recovery systems where they are source-selected and sent to a recycler specializing in this particular item are specifically excluded from this guide.

APR's DEFINITION OF RECYCLABLE

An item is "recyclable per APR definition" if:

- At least 60% of consumers or communities have access to a collection system that accepts the package

- It is most likely sorted correctly into a market-ready bale of a particular plastic meeting industry standard specifications, through commonly used material recovery systems, including single-stream and dual stream MRFs, PRF's, systems that handle deposit system containers, grocery store rigid plastic and film collection systems.
- It can be further processed through a typical recycling process cost effectively into a postconsumer plastic feedstock suitable for use in identifiable new products.

APR's RECYCLABILITY CATEGORIES

The APR Design® Guide is itemized by package design feature. The recycling impact of each design feature is discussed within the Guide. The APR's position on the design feature is developed considering this impact and broken down into four categories which should be thoroughly understood:

- ***APR DESIGN GUIDE® PREFERRED:*** Features readily accepted by MRFs and recyclers since the majority of the industry has the capability to identify, sort, and process a package exhibiting this feature with minimal negative effect on the operation or final product quality. Packages with these features are likely to pass through the recycling process into the most appropriate material stream with the potential of producing high quality material.
- ***DETRIMENTAL TO RECYCLING:*** Features that present known technical challenges for the MRF or recycler's operations, yield or final product quality, but are grudgingly tolerated and accepted by the majority of MRFs and recyclers.
- ***RENDERS PACKAGE NON-RECYCLABLE PER APR DEFINITION:*** Features with a significant adverse technical impact on the MRF or recycler's operations, yield, or final product quality. The majority of MRFs or recyclers cannot remove these features to the degree required to generate a marketable end product.
- ***REQUIRES TESTING:*** In order to determine the appropriate APR recyclability category, testing per the APR testing protocol is required. The APR category is dependent on the test result.

DISCLAIMER

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

The Association of Plastic Recyclers

APR Design® Guide for Plastics Recyclability for Polypropylene (PP, Resin Identification Code #5)

Due to its balance of impact, heat and chemical resistance, along with stiffness and close dimensional tolerance, PP is one of the most widely used packaging resins. It is easily injection molded, blow molded or thermoformed into a bottle, pail, tray, tub or closure. Unlike some other polymers, the versatility of PP allows all components (label, body and closure) of many PP packages to be made of PP. This practice is beneficial to recycling.

PP properties are commonly enhanced with colorants, additives and fillers, or it is placed alongside other polymers in a multi-layer package. Each modification and addition to the natural PP in a package must be considered for its effect on the recycling stream. Non-PP packaging features should either be economically removed from the PP in the typical recycling process or be compatible with PP in future uses. Of particular concern are mineral fillers or additives that cause the overall density of the blend to be greater than 1.00. The density of PP is .90-.92 so it floats in water. Density is an important property as reclaimers typically rely on float-sink tanks to separate polymers and to remove contaminants.

Per the scope outlined in the Design Guide introduction, the following guidance is focused on postconsumer packaging items that are typically picked up in single stream curb side collection systems. Further the guidance considers the impact on sortation at a modern automated MRF or PRF, as well as the compatibility of a PP packaging item in common PP reclaiming processes. This guidance will also be applicable to other postconsumer household items such as toys.

PP is used in a wide number of industrial applications and postindustrial PP is an important source of PP that is collected and recycled. The APR Design® Guide can be a reference when designing industrial applications with PP, but not all guidance may be applicable when recyclability of such commercially used items is being considered.

The APR Recognition Program encourages consumer product, plastic package and bottle component manufacturers to work with the APR protocols to determine whether new modifications to a regularly recycled plastic package will negatively impact the recycling process prior to introducing the modification.

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FEATURE	RECYCLABILITY CATEGORIES				TEST	
	APR DESIGN GUIDE® PREFERRED	REQUIRES TESTING	DETRIMENTAL TO RECYCLING	RENDERS PACKAGE NON-RECYCLABLE PER APR DEFINITION	SCREENING/BENCHMARK TEST (indicative only - see definition of Screening and Benchmark tests)	DEFINITIVE TEST
BASE POLYMER						
Postconsumer Polyolefin content	X					
BARRIER LAYERS, COATINGS & ADDITIVES						
EVOH Layers	X					
Non-PP layers and coatings other than EVOH		X			PP Benchmark Test	
Degradable additives		X			HDPE/PP Degradeable additives Test	
Workhorse additives historically used without issue (see list in the guide)	X					
Additives not listed		X			PP Benchmark Test	
Total additive concentration causing material to sink				X	PO Float Test - development in progress	
COLOR						
Unpigmented	X					
Optical brighteners			X			
translucent and opaque colors	X					
Dark color with L value <40 or NIR reflectance <=10%		X			Test Method to Evaluate the NIR Sorting Potential of a Whole Plastic Article	
DIMENSIONS						
More 2 dimensional than 3 dimensional (one dimension <=1")				X		
Two dimensions less than 2"		X			Evaluation of Size Sorting Potential for Articles with at Least 2 Dimensions Less Than 2"	
Greater than 2 gallons in volume	X					
CLOSURES AND DISPENSERS						
Polypropylene	X					
Polyethylene			X			
Closure systems without liners	X					
EVA and TPE liners in plastic closures	X					
Pumps and spray disensers containing metal parts		X			Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components	
Metal parts and foils		X			Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components	
Floating silicone polymer parts			X			
PVC			X			
Metal lidding			X			
Polystyrene or thermoset	X					

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FEATURE	RECYCLABILITY CATEGORIES				TEST	
	APR DESIGN GUIDE® PREFERRED	REQUIRES TESTING	DETRIMENTAL TO RECYCLING	RENDERS PACKAGE NON-RECYCLABLE PER APR DEFINITION	SCREENING/BENCHMARK TEST (indicative only - see definition of Screening and Benchmark tests)	DEFINITIVE TEST
GENERAL LABELS, INKS AND ADHESIVES						
Inks		X			PP/HDPE Bleeding Label Test - development in progress	
Direct printing other than date coding		X			PP Benchmark Test	
In-mold labels of a compatible polymer	X					
Full bottle sleeve labels designed for sorting	X					
Adhesives		X			PP/HDPE Adhesive Test - TBD (3 outcomes: wash releasable, not wash releasable-compatible, not wash releasable-non compatible)	
Labels With Non Wash Releasable, PP Compatible Adhesives						
PP, PE labels	X					
Paper labels			X			
Metal foil, metalized or metallic printed labels		X			Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components	
PVC or PLA labels				X		
Polystyrene labels			X			
Labels With Wash Releasable Adhesives						
PP, PE labels	X					
Paper labels		X				
Metal foil labels	X					
PVC labels		X				
PLA labels	X					
Polystyrene labels	X					
ATTACHMENTS						
PP - PE Tamper evident safety sleeves	X					
PETG Tamper evident safety sleeves	X					
PVC Tamper evident safety sleeves			X			
Non-PP attachments		X			PP Benchmark test	
Metal and metal containing		X			Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components	
Plastic with a density > 1.0 except PVC	X					
Welded attachments		X			PP Benchmark test	
PE			X			
RFID's			X			
PLA		X				
PVC			X			

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BASE POLYMER

Postconsumer polyolefin content is preferred.
The use of postconsumer PP in all packages is encouraged to the maximum amount technically and economically feasible.

BARRIER LAYERS, COATINGS & ADDITIVES

The use of non-PP layers and coatings can be detrimental to recycling of PP if not implemented according to APR test protocols. When used, their content should be minimized to the greatest extent possible to maximize PP yield, limit potential contamination, and reduce separation costs.

EVOH layers are preferred.
EVOH is a common layer material used to increase the barrier properties of PP. It is not separable in the recycling process and therefore will become part of the recycled PP. Although EVOH blended with PP is not without issue (it may cause splay when extruded or molded and contribute to die lip build up) it is generally accepted. EVOH has performed successfully in previous critical guidance tests. Some recycled PP users have experienced molding problems at values approaching 3%. Its use should be minimized to maintain the best performance of recycled PP for future uses.

Non-PP layers and coatings other than EVOH require testing to determine the appropriate APR recyclability category. Testing must show that layers and coatings will either separate and be removed from the PP in the recycling process or have no adverse effects on the recycled PP in future uses. When used, their content should be minimized to the greatest extent possible. Some layers and coatings have been found compatible with PP or are easily separated in conventional recycling systems.

Test Protocol: PP Benchmark Test

Degradable additives (photo, oxo, or bio) require testing to determine the appropriate APR recyclability category. Recycled PP is intended to be used in new products. The new products are engineered to meet particular quality and durability standards given properties of typical recycled PP. Additives designed to degrade the polymer by definition diminish the life of the material in the primary use. If not removed in the recycling process, these additives also shorten the useful life of the product made from the recycled PP, possibly compromising quality and durability.

Degradable additives should not be used without testing to demonstrate that their inclusion will not materially impair the full-service life and properties of any product made from the recycled PP that includes the additive. Testing must show that these additives will either separate and be removed from the PP in the recycling process or have no adverse effects on the recycled PP in future uses. When used, their content should be minimized to the greatest extent possible.

Screening Test: HDPE/PP Degradable Additives Test

Workhorse additives historically used without issue are preferred.
Most PP in a package contains some form of additives. The "workhorse" additives commonly used have not been shown to cause significant issues with the recycling process or further uses of the recycled PP. Commonly acceptable workhorse additives include:

- Thermal stabilizers - These additives typically enhance the further processing of the polymer and are therefore preferred for recycling.
- UV stabilizers – These additives typically enhance the further processing of the polymer and are therefore preferred for recycling
- Nucleating agents
- Clarifying agents
- Antistatic agents
- Lubricants
- Fillers – note that many fillers are dense, so particular attention should be paid to the overall blend density
- Pigments
- Impact improvers
- Chemical blowing agents

Additive usage should be minimized to maintain the best performance of recycled PP for future uses.

Additives not listed require testing to determine the appropriate APR recyclability category. The APR recognizes that other types of additives may be required for the performance of a particular package but are not addressed in this document. Of particular concern are additives which cause the recycled PP to discolor or change viscosity after remelting, or dense additives that will increase the density of the blend over 1.0, thus rendering the package unrecyclable per APR definition. The APR encourages users to test the additive according to the appropriate test protocol before implementing. Testing must show that additives will not cause unacceptable discoloration, viscosity changes, or density changes.

Test Protocol: PP Benchmark Test

Additive concentration causing the overall blend to sink renders the package non-recyclable per the APR definition. Many of the additives and fillers used with PP are very dense and when blended with the polymer increase the overall density of the blend. When their weight percentage reaches the point that the blend density is greater than 1.00, the blend sinks in water rather than floats. Density is an important property and float-sink tanks are critical separation tools used by reclaimers. Therefore, a sinking material will be considered waste by a polypropylene reclaimer and any PP in the blend will be lost. The APR test protocol should be consulted to determine if a blend sinks.

COLOR

Unpigmented PP is preferred.
Natural material has the highest value as a recycled stream since it has the widest variety of end-use applications. It is the most cost effective to process through the recycling system.

Optical brighteners are detrimental to recycling.
Optical brighteners are not removed in the recycling process and can create an unacceptable fluorescence for next uses of recycled PP. It is difficult to identify material with this negative effect until extremely late in the recycling process where a great deal of added cost has been imparted into a material of low value due to the additive.

Translucent and opaque colors are preferred.
PP is commonly colored so volumes and markets exist for colored material and it is economical to process.

Colors with an L value less than 40 or an NIR reflectance less than or equal to 10 percent require testing to determine the appropriate APR recyclability category.
There is no mechanical property inherent in dark PP that makes it unrecyclable. The problem lies in sorting and the physics behind polymer identification. NIR (near-infrared) sorting technology used in MRFs is not capable of identifying many dark polymers since the colorant absorbs light. There are dark shades that may be detected by NIR, and a PP label of a different color on a package might aid in detection by NIR. It is not feasible to use manual sorting to distinguish one dark polymer from another since there are just too many items.

Although the APR encourages and anticipates development in capturing dark plastics at the MRF this technology is not widely available today. It should be noted that black is a commonly used color in PP, particularly in industrial items. These items fall outside the scope of the design guide since they are not typically collected through curbside collection that is the focus of this guidance. Non-NIR sortable PP, if collected in a source separated or postindustrial stream, can be reclaimed.

> **Benchmark Test**: Test Method to Determine the Near Infrared Sorting Potential of a Whole Plastic Article

DIMENSIONS

Size and shape are critical parameters in MRF sorting, and this must be considered in designing packages for recycling. The MRF process separates items by size and shape first, then by material. Screens direct paper, and similar two-dimensional lightweight items, into one stream; containers and similar three-dimensional heavier items into another steam; while broken glass and smaller but heavy items are allowed to drop by gravity to yet another stream, which may or may not be further sorted. Large, bulky items are typically manually sorted on the front of the MRF process.

Items more two-dimensional than three-dimensional render the package non-recyclable per APR definition.
Aside from not being captured in the plastic stream, they cause contamination in the paper stream. Items should have a minimum depth of two inches in order to create a three-dimensional shape for proper sorting. This issue is unrelated to the polymer type. The APR encourages and anticipates developments in MRF design and technology to improve capture and recovery of thin plastics; however, at the current time this technology either does not exist or is uninstalled in the majority of MRFs.

Items smaller than 2 inches in 2 dimensions render the package non-recyclable per APR definition.
The industry standard screen size loses materials less than three inches to a non-plastics stream, causing

contamination in that stream, or directly to waste. These small packages are lost to the plastic recycling stream. It is possible that some small containers travel with larger ones when either the screens wrap with film or they are operated above their design capacity. Film wrapping reduces the effective size of the screen and over-running provides a cushion of large items on which the smaller items travel. The design guidelines use clean screens operating at their design capacity for the determination of the recyclability category. The APR anticipates and encourages technology development to improve the process of small package recovery but currently these items are not recovered.

> **Benchmark Test**: Evaluation of Size Sorting Potential for Articles with at Least 2 Dimensions Less than 2 Inches

Polyethylene or Polypropylene are preferred for items greater than two gallons in volume.
Recycling machinery, particularly automatic sorting equipment, is not large enough to accept items larger than two gallons. Because larger containers jam the systems, most MRFs employ manual sortation before the automatic line to remove the large items. These items are recovered in a stream of bulky rigid containers that are sold and processed as polyethylene since the vast majority of bulky rigid items are comprised of this polymer. Other polymers either negatively affect or are lost by the polyethylene processing.

CLOSURES & DISPENSERS

Polypropylene closures are preferred.
Because polypropylene is the same polymer as the package body, closures and dispensers made of it will be captured and processed with PP. This increases the reclaimers yield and reduces possible waste.

Polyethylene closures are detrimental to recycling.
Because polyethylene floats in water like polypropylene, it is not separated in the reclaimers float-sink tank. When blended with PP it negatively affects stiffness and impact properties. Although very small amounts of PE, such as that contributed by labels, are regularly accepted by PP reclaimers, closures and dispensers comprise a larger weight percentage of the package and therefore a greater negative affect.

Closure systems without liners are preferred.
Due to size and thickness, most liners are lost in the recycling process thereby slightly decreasing yield. Closures without liners do not experience this loss.

EVA and TPE liners in plastic closures are preferred.
EVA and TPE float in water and will not be separated in the recycling process. However, they are compatible with PP and in fact enhance its properties so they are preferred.

Pumps and spray dispensers containing metal parts require testing to determine the appropriate recyclability category. Although metal is easily removed in the float-sink process, most reclaimers have metal detection equipment designed to protect their cutting machinery. Therefore, the container never makes it to the float-sink tank. Large metal items attached to PP packages may cause the package to be directed to the metal or waste stream in the recycling process, causing yield loss. Metal springs, although not generally large enough to trigger the metal detector, unravel during recycling and entwine themselves in screens designed to separate

water from the material thereby ruining the screen. This adds significant cost and downtime to the recycling process. The APR encourages the use of polymer check valves and springs whenever technically possible. The body of the spray dispenser or pump should also be the same polymer as the body of the bottle whenever technical possible to increase yield and decrease contamination of the recycled PP.

> **Benchmark Test**: Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Closures containing metal or metal foils require testing to determine the appropriate recyclability category.
Although metal is easily removed in the float-sink process, most reclaimers have metal detection equipment designed to protect their cutting machinery. Therefore, the container never makes it to the float-sink tank. Large metal items attached to PP packages may cause the package to be directed to the metal or waste stream in the recycling process, causing yield loss.

> **Benchmark Test**: Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Closures containing floating silicone polymer are detrimental to recycling.
This material passes through the float-sink tank along with the PP and is difficult to remove with other methods, thereby causing contamination in the final product. It should be noted that sinking silicone does not experience this issue.

The use of PVC closures is detrimental to recycling.
PVC is relatively easy to remove in the float-sink tank since it sinks while the PP floats. However, the float-sink tank is imperfect and even a very small amount of PVC with the recycled PP renders large amounts of it unusable as the PVC degrades at lower temperatures than those at which PP is processed.

Closures made from polystyrene or thermoset plastics are preferred.
Both materials are heavier than water and sink in the float-sink tank, thereby separating from the PP. They also do not damage or wear cutting machinery in the recycling process. Small amounts of these materials that make it through the float-sink process can be melt filtered from the recycled PP in the extrusion step. However, these materials are lost to the waste stream in the recycling process and are considered less preferable than an alternative floating attachment that is compatible with PP.

LABELS, INKS AND ADHESIVES

Label inks require testing to determine the appropriate APR recyclability category.
Some label inks bleed color in the reclamation process, discoloring the PP in contact with them and possibly diminishing its value for recycling. Since most recycled PP is colored, the impact of bleeding inks may not be significant; however, since the end use is not known beforehand, label inks should be chosen that do not bleed color when recycled. The APR test protocol should be consulted to determine if an ink bleeds.

> **Screening Test**: PP/HDPE Bleeding Label Test

Direct printing other than date coding requires testing to determine its compatibility with the recycling system. Inks used in direct printing may bleed, otherwise discolor the PP during the recycling process, or introduce incompatible contaminants. In either case, the value of the recycled PP may be diminished. Some inks used in direct printing do not cause these problems. The specific ink must be tested to determine its effect.

Test Protocol: PP Benchmark Test

In-mold labels of a compatible polymer are preferred.
In-mold labels are not removed in the recycling process since they are bonded with the wall of the package. They will flow though the recycling process with the PP and be blended with the recycled PP. The lack of adhesive is beneficial to recycling since it cannot affect color or other mechanical properties. The label polymer and ink should be compatible with PP so as not to negatively affect its properties.

Full bottle sleeve labels designed for sorting are preferred.
A positive aspect of sleeve labels is the lack of adhesive requiring removal in the recycling process. However, full bottle sleeve labels cover a large amount of the bottle surface with a polymer that is not the same as the bottle body. Because of this, a sleeve label designed without considering sorting may cause an automatic sorter to direct a PP bottle to another material stream where it is lost to the process. Furthermore, some incompatible sleeve materials that cannot be separated from the PP in the float-sink tank can contaminate the recycled PP produced. Sleeve labels that are designed for automatic sorting and sink in water are preferred, with the exception of PVC, where even small residual amounts that make it through the float-sink process will destroy the recycled PP in the extrusion process. Polyolefin sleeve labels that are designed for automatic sorting are also preferred since the small levels of completely incompatible material expected from label residue has a very minimal negative impact.

Adhesives require testing to determine the appropriate APR recyclability category.
Testing must show that adhesives will either wash off cleanly from the PP in the recycling process or be compatible with PP. However, typical PP recycling process conditions are not aggressive enough to remove all adhesive material, and a certain amount of residual adhesive is to be expected in recycled PP. Adhesive that is not removed from PP during the wash step is a source of contamination and discoloration when PP is recycled. For these reasons, minimal adhesive usage is encouraged.

The APR is developing a PP/HDPE adhesive test to classify adhesive as either wash friendly, non-wash friendly and compatible with PP, or non-wash friendly and incompatible with PP. Non-wash friendly, incompatible adhesive is detrimental to recycling.

One test protocol is under development: PP/HDPE Adhesive Test

Label-Adhesive Combinations

The classification and recyclability of label substrates is dependent on the type of adhesive that is used with them. In general, a label substrate that sinks in water and is used with an adhesive that releases in the reclaimers wash system is preferred since the substrate will be removed in the float-sink tank. A label substrate that is compatible with PP is also preferred no matter what the adhesive. Therefore, label substrates are classified by the type of adhesive used with them.

Polypropylene or polyethylene labels are preferred.
PP labels are the same polymer as the final product and PE at the very small levels expected from label residue has a very minimal negative impact. Therefore, these labels that remain with the PP throughout the recycling process, whether they detach or not, increase yield and have minimal negative quality impact for the reclaimer.

Paper labels are detrimental to recycling.
The PP reclamation process involves water and agitation. The paper that detaches from the container when subjected to these conditions becomes pulp, which does not sink intact but remains suspended in the liquid, adding load to the filtering and water treatment systems. Paper remaining adhered to the PP travels with the PP to the extruder where the material carbonizes and causes color defects. Even after melt filtering, the burned smell and discoloration remain with the recycled PP thereby negatively affecting its potential reuse. Non-pulping paper labels used with non-releasing adhesives compound the problem since the entire label enters the extruder. Non-pulping labels, heavy enough to sink and durable enough to withstand the washing process that are used with releasing adhesives may alleviate this issue.

Metal foil labels are detrimental to recycling when used with an adhesive that does not release in the wash and preferred when used with an adhesive that releases in the wash.
In the MRF, even very thin metallized labels may be identified as metal by the sorting equipment and cause the entire bottle to be directed to the metal stream, thereby creating yield loss. Sorting equipment in the reclaiming process is designed to detect and eliminate metal from PP. If small, not detected, or allowed to pass, these labels, when used with an adhesive that does not release in the wash, either cause the attached PP to sink where it is lost in the float-sink tank or pass into the extruder and are removed with melt filtering. When used with an adhesive that releases in the wash, these labels quickly sink in the float sink tank where they are removed

PVC labels render the package non-recyclable per APR when used with an adhesive that does not release in the wash and detrimental to recycling when used with an adhesive that releases in the wash.
PVC, when used with an adhesive that does not release in the wash, enters the extruder with the PP where they are incompatible. PVC degrades at PP extrusion temperatures and renders large amounts of the recycled PP unusable. When used with an adhesive that releases in the wash, these labels sink in the float-sink tank where they are removed. But because the float-sink tank is imperfect, and even a very small amount of PVC entering the extruder causes severe quality and yield problems, this material is detrimental.

PLA labels render the package non-recyclable per APR when used with an adhesive that does not release in the wash and preferred when used with an adhesive that releases in the wash.
PLA label material, when used with an adhesive that does not release in the wash, enters the extruder with the PP where they are incompatible. When used with an adhesive that releases in the wash, the PLA detaches from the PP before the float-sink tank where it sinks and is removed. Even though the float-sink process is imperfect, the small amounts of PLA entering the extrusion process are not catastrophic

Polystyrene labels are detrimental to recycling when used with an adhesive that does not release in the wash and preferred when used with an adhesive that releases in the wash.
PS, when used with an adhesive that does not release in the wash, remains with the PP and enters the extruder where it is blended with the PP. PS is not compatible with PP and may cause splay or reduce impact toughness for the recycled PP user. PS label material, when used with an adhesive that releases in the wash, detaches from

the PP before the float sink tank where it sinks and is removed.

ATTACHMENTS

Polypropylene or polyethylene tamper evident safety sleeves are preferred.
PP safety sleeves are the same polymer as the final product, and PE at the very small levels expected from safety sleeve residue has a very minimal negative impact. Therefore, these attachments that remain with the PP throughout the recycling process increase yield and have minimal negative quality impact for the reclaimer.

PETG tamper evident safety sleeves are preferred.
PETG sinks in the float sink tank where it is removed from the PP. Unlike PVC, small amounts of PETG entering the extrusion process with the PP are not catastrophic since PETG can be melt filtered.

PVC tamper evident safety seals are detrimental to recycling.
PVC sinks in the float-sink tank where the majority of it is removed from the PP. Because the float sink tank is imperfect and even a very small amount of PVC entering the extruder causes sever quality and yield problems, this material is detrimental. PVC degrades at PP extrusion temperatures and renders large amounts of the recycled PP unusable.

Non-PP attachments require testing to determine the appropriate APR recyclability category.
Testing must show that these attachments are not adhesively bonded to the package and are made from materials that sink in water so they readily separate from the package when ground and put through a float-sink separation. If adhesives are used to affix attachments, their selection should consider the adhesive criteria within this document.

> **Test Protocol**: PP Benchmark Test

Metal, metalized and metal-containing attachments require testing to determine the appropriate APR recyclability category. Metal or metal-containing attachments may cause NIR sorters in MRFs to misidentify a PP container as metal and direct it to a metal stream, from which it is then discarded. Sorting equipment in the reclaiming process is designed to detect and eliminate metal from PP in order to protect cutting machinery. Large items, or items adhesively bonded to the PP, can damage the machinery and render the entire package non-recyclable. If small, not detected, or allowed to pass, metals, when used with wash friendly or no adhesive quickly sink in the float sink tank where they are removed from the PP.

> **Benchmark Test**: Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Plastic attachments with a density > 1.00 except for PVC are preferred.
These items sink in the sink-float tank where they are removed from the PP and small residual amounts do not severely affect the final product since many of them are melt filtered. PVC is detrimental as discussed elsewhere in this document.

Welded attachments require testing to determine the appropriate APR recyclability category.

A certain amount of a welded attachment cannot be separated from the PP in the recycling process. These attachments may cause recycled PP contamination and yield loss issues in both cases: when the ground section containing both polymers sinks and carries the PP with it, or when the ground section floats and carries an incompatible material with the PP into the extrusion process. Testing must show that the blend is of a density less than 1.0 so that it floats along with the PP in the float-sink tank, and that it is compatible with PP in the extrusion process.

Polyethylene attachments are detrimental to recycling.
Because polyethylene floats in water like polypropylene, it is not separated in the reclaimers float-sink tank. When blended with PP it negatively affects stiffness and impact properties. Although very small amounts of PE, such as that contributed by labels, are regularly accepted by PP reclaimers, some attachments comprise a larger weight percentage of the package and therefore a greater negative affect.

RFID's (radio frequency identification devices) on packages, labels or closures are detrimental to recycling.
RFID's are printed on silver metal, which may create costly waste disposal issues. While RFID's are small, they may affect PP recycling in the same ways as metal labels or other attachments. The use of RFID's is discouraged as may limit PP yield, introduce potential contamination, and increase separation and waste disposal costs.

PLA attachments are preferred.
As discussed in the sections on labels and closures, PLA sinks in the float-sink tank and can be therefore removed from the PP. Unlike PVC, small amounts of PLA entering the extrusion process are not catastrophic

PVC attachments are detrimental to recycling. PVC sinks in the float sink tank where the majority of it is removed from the PP. Because the float sink tank is imperfect and even a very small amount of PVC entering the extruder causes sever quality and yield problems, this material is detrimental. PVC degrades at PP extrusion temperatures and renders large amounts of the recycled PP unusable

RESIN IDENTIFICATION CODE, RIC

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