The Association of Plastic Recyclers

The APR Design® Guide for Plastics Recyclability is the most comprehensive and user-friendly resource outlining the plastics recycling industry's recommendations in the marketplace today. The content has been updated to present a more easily accessed, clearer picture of APR's Recyclability Categories representing 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 full written 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 its Champions for Change® and Responsible Innovation programs, as well as the APR Design® Guide to create the most recyclable packaging. Assistance is available through APR, APR members, and independent laboratories found in the member directory.

Furthermore, this guide is intended to identify potential areas of improvement, and encourage innovation both in package design and recycling process equipment.

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

The Association of Plastic Recyclers

APR Design® Guide for Plastics Recyclability
for
PET (Polyethylene Terephthalate, Resin Identification Code #1)

BACKGROUND: Due to its clarity and natural CO2 barrier properties, PET is one of the most widely used packaging resins. It is easily blown into a bottle or formed into a sheet, thereby becoming the resin of choice for many applications. PET does not normally have the desired properties for closures, handles, attachments or labels so other polymers are commonly used for these items and affixed to the PET package. PET properties can be enhanced with colorants, UV blockers, oxygen barriers/scavengers and other additives. Each modification and addition to the base, clear PET in a package must be considered for its effect on the recycling stream. Items should either be economically removed from the PET in the typical recycling process or be compatible with RPET in future uses. The density of PET is 1.38 and so it sinks in water. Closures, labels and attachments should be made from materials with a density less than 1.0 that will float in water and therefore be readily separated from the PET.

The APR's Champions for Change® 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.

The Association of Plastic Recyclers

THE APR DESIGN GUIDE® RECYCLABILITY CATEGORIES AT A GLANCE - PET

FEATURE	APR DESIGN GUIDE® PREFERRED	REQUIRES TESTING	DETRIMENTAL TO RECYCLING	RENDERS PACKAGE NON-RECYCLABLE PER APR DEFINITION	LINK TO	
					SCREENING/BENCHMARK TEST (indicative only - See definition of Screening and Benchmark tests)	DEFINITIVE TEST
BASE POLYMER:						
PET with a crystaline melting point between 235-245 C	X					
Post consumer RPET content	X					
Blends of PET and other resins		X				PET critical guidance
BARRIER LAYERS, COATINGS & ADDITIVES						
Non-PET layers and coatings		X			Quick Test for Color	PET Critcal Guideance
Degradable additives		X			PET Degradable Additives Test	
Additives		X			Quick Test for Color	PET Critcal Guideance
Optical brighteners			X			
COLOR						
Clear unpigmented	X					
Transparent light blue	X					
Transparent green	X					
Transparent colors other than green and light blue			X			
Translucent and opaque colors including white			X			
Nucleating agents, hazing agents, fluorescers, and other additives for visual and technical effects			X			
Black color				X		
DIMENSIONS						
More 2 dimensional than 3 dimensional (one dimension <2")				X		
All three dimensions < 3"				X		
Greater than 2 gallons in volume			X			
CLOSURES AND DISPENSERS						
Polypropylene or Polyethylene	X					
Closure systems without liners	X					
EVA and TPE liners in plastic closures	X					
Metal parts and foils		X			New eddy current and magnetic test for attachments	Closure Test
Polystyrene or thermoset plastics			X			
Silicone polymer parts			X			
PVC				X		
LABELS INKS AND ADHESIVES						
PP or PE with specific gravity less than 1.0	X					
Full bottle sleeve labels		X				Sleeve Label Test
Pressure sensitive labels		X			Thermoform Label Test	Pressure Sensitive Label Test
Polystyrene labels		X			Labels, Closures and Attachments Floatability Test	
Label systems that sink in water because of substrate, inks, decoration, coatings, and top layer		X				PET Critical Guidance
Paper labels (for pressure sensitive use pressure sensitive category)			X			
Metal foil labels			X			
PVC and PLA labels				X		
Adhesives		X			PET Flake WashTest/Thermoform Label Test	PET Critical Guideance
Non-water soluble/dispersible adhesives			X			
Inks		X			Bleeding Label Test/Flake to Plaque Bleeding Label Test	See appropriate test for label type
Direct printing other than date coding		X			Bleeding Label Test/Flake to Plaque Bleeding Label Test	Direct Print Label Test
ATTACHMENTS						
Clear PET	X					
Tamper evident sleeves and safety seals		X			Labels, Closures and Attachments Floatability Test	PET Crtical Guidance
Non-PET attachments		X			Labels, Closures and Attachments Floatability Test	PET Crtical Guidance
Metal and metal containing		X			New eddy current and magnetic test for attachments	
Paper			X			
Welded attachments			X			
RFID's			X			
PVC and PLA				X		

This document is intended to be used as a summary and quick reference of some selected items within the Design Guide for Plastics Recyclability. In no manner is it intended or implied to be a replacement for the actual document.

➢ BASE POLYMER:

- PET and PET variants resins which have a crystalline melting point between 235 and 255C are preferred. Materials of a lower melt point or non-crystalline materials often become sticky in the reclaimers' pre-extrusion dryer when the dryer is operated at PET temperatures and prevent the material from flowing through the process. Materials of a higher melt point remain solid in the reclaimers' extruder and cause blockages in melt screens. Both conditions greatly hinder the ability of the reclaimer to operate.

- Blends of PET and other resins require testing to determine the appropriate APR recyclability category. Other resins may be blended into the PET to enhance certain properties during the package's intended first use. The materials' effect on the RPET in future uses must be evaluated since it will not be removed in the recycling system.

  One test protocol is available:
  Definitive Test: PET Critical Guidance

➢ BARRIER LAYERS, COATINGS & ADDITIVES

- Non-PET layers and coatings require testing to determine the appropriate APR recyclability category. The use of non-PET layers and coatings can be detrimental to recycling of PET if not implemented according to APR test protocols. Layers and coatings must either separate and be removed from the PET in the recycling process or have no adverse effects on the RPET in future uses. When used, their content should be minimized to the greatest extent possible to maximize PET yield, limit potential contamination, and reduce separation costs. Some layers and coatings have been found compatible with PET or are easily separated in conventional recycling systems.

  Two test protocols are available:
  Screening Test: Quick Test for Color
  Definitive Test: PET Critical Guidance

- Degradable additives (photo, oxo, or bio) require testing to determine the appropriate APR recyclability category. Recycled PET 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 PET. Additives designed to degrade the polymer diminish the life of the material in the primary use. If not removed in the recycling process, these additives shorten the useful life of the product made from the RPET as well, 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 RPET that includes the additive. These additives must either separate and be removed from the PET in the recycling process or have no adverse effects on the RPET in future uses. When used, their content should be minimized to the greatest extent possible to maximize PET yield, limit potential contamination, and reduce separation costs.

  One test protocol is available:

Screening Test: PET Degradable Additives Test

- Additives 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. Additives such as de-nesting, anti-static, anti-blocking, anti-fogging, anti-slip, UV barrier, stabilizer and heat receptor agents and lubricants should be tested to determine their compatibility with recycling. Of particular concern are additives which cause the RPET to discolor or haze after remelting or solid stating since RPET with poor haze or discoloration is greatly devalued and has limited markets. This is particularly troublesome since it is difficult to identify material with this effect until extremely late in the recycling process where a great deal of added cost has been imparted into the material.

  Two test protocols are available:
  Screening test: Quick Test for Color
  Definitive Test: PET Critical Guidance

- Optical brighteners are detrimental to recycling. Like many other additives, optical brighteners are not removed in the recycling process and can create an unacceptable fluorescence for next uses of RPET containing the brighteners. 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.

COLOR

- Clear unpigmented PET is preferred. Clear 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.

- Transparent light blue packaging is preferred. Light blue material is most often included with the clear material stream to act as a bluing agent and offset some yellowing. This not only adds volume to the high value clear stream, it improves its quality when used in limited amounts. Normally it can also be added to the green stream with little negative effect

- Transparent green packaging is preferred. Green material has significant volume in the marketplace. At the MRF, it is baled along with the clear PET and may comprise up to 30% of the PET bale. The green material is separated from the clear by the original reclaimer, who may process it into a value-added product, or send it to a reclaimer dedicated to green material. Its value is second only to clear material. However, green is not without its issues. Because a consistent, clear color is critical to future products using clear RPET, the recycling process includes a great deal of machinery and manpower dedicated to separating colored material. This adds significant cost to the operation. Even so, small but significant amounts of colored material, including transparent green, pass into the clear stream, thereby affecting the quality of clear RPET. Markets such as clothing, carpet, soft drink bottles and thermoformed sheet depend on very precise colors using clear material as a basis

- Transparent colors other than green and light blue are detrimental to recycling. These colors when separated from the primary clear and green streams are small in volume with little market value. Some reclaimers are able to tolerate transparent amber tinted bottles in their systems but these are limited.

- Translucent and opaque colors including white are detrimental to recycling. There is very little market value for this material and it contaminates the other streams that have value. It can also be very difficult for automatic sorters to identify opaque colored polymers so additional labor must be employed to remove opaque materials

- Nucleating agents, hazing agents, fluorescers, and other additives for visual and technical effects are detrimental to recycling. Like many additives, these features are not removed in the recycling process and can affect the value of the RPET and its performance in future uses.

- Black color renders the package non-recyclable. NIR sorting technology is not capable of identifying a black polymer and manual sorting cannot distinguish one black polymer from another. Oth**er** separation techniques such as float-sink cannot be employed since many black polymers sink with PET. Therefore, black packaging is considered a contaminant for nearly all reclaimers.

➢ 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 3 inches in all 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.

- Items greater than two gallons in volume are detrimental to recycling. 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 and polyethylene closures are preferred. Since these polymers float, they are most easily separated from the bottle in conventional separation systems. Additionally, the PET recycling process captures floatable polyethylene and polypropylene to create an ancillary stream of marketable material. Care must be taken when modifying the polyethylene or polypropylene to ensure the modifier does not increase the overall density to the point it sinks.

- 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. Both EVA and TPE float in water and will be separated in the recycling process with the floatable polyethylene and polypropylene. Since EVA and TPE are compatible with these polymers, and in fact enhance their properties, they are preferred.

- Closures containing metal or metal foils require testing to determine the appropriate APR recyclability category. Metal is difficult to separate from PET compared to the preferred closure systems (polypropylene and polyethylene) and adds both capital and operating costs to conventional reclamation processes. Even a small amount of metal left in the RPET stream will block extruder screens in remanufacturing. Large metal items attached to PET packages may cause the package to be directed to the metal or waste stream in the recycling process, causing yield loss. Small metal components such as spray dispenser springs unravel in the recycling process and blind screens, adding significant cost for removal at the end of the process.

  Two test protocols are available:
  Screening Test: New Eddy Current and Magnetic Test for Attachments
  Definitive Test: Closure Test

- Closures made from polystyrene or thermoset plastics are undesirable for recycling. Both materials are heavier than water and sink in the float-sink tank with PET. They are extremely difficult to separate from RPET flake, requiring a costly and inexact polymer flake sorter currently not installed in many reclaiming operations.

- Closures containing silicone polymer are detrimental to recycling. Silicone sinks in the float-sink tank with the PET and is difficult to remove with other methods, thereby causing contamination in the final product.

- The use of PVC closures or closure liners render the package non-recyclable per APR. PVC sinks and is extremely hard for the recycler to remove, particularly in small pieces. The recycled PET stream is very intolerable to even minute amounts of PVC.

➢ LABELS, INKS AND ADHESIVES

Removing adhesives is a significant component to the cost of recycling. The most recyclable packages use the lowest quantity of recycle-friendly adhesive. Lower adhesive usage reduces processing cost and potential contamination risk.

- Polypropylene or polyethylene labels with a specific gravity less than 1.0 are preferred. These materials float in water so they are separated from the PET in the float-sink tank with the closures. Since they are the same general polymer as most of the closures they do not contaminate or devalue this stream. Care should be taken to ensure that any modifiers to the label material do not increase its density above 1.0.

- Laminated labels require testing to determine the appropriate APR recyclability category. Labels that break into small, very thin pieces of material are more difficult to manage in the recycling process because they behave erratically in a float-sink tank. Therefore, labels that stay intact are preferred. Carry-over of delaminated labels into the RPET can result in contamination.

  One test protocol is available:
  Definitive Test: New Delamination Test

- Full bottle sleeve labels require testing to determine the appropriate APR recyclability category. 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 recycling may cause a false reading on an automatic sorter and direct a PET bottle to another material stream where it is lost to the process. Furthermore, some sleeve label materials cannot be removed in the recycling process and contaminate the RPET produced. Sleeve labels that have been found compliant with the APR test protocols should be selected.

  One test protocol is available:
  Definitive Test: Sleeve Label Test

- Pressure sensitive labels require testing to determine the appropriate APR recyclability category. Pressure sensitive labels generally require complete adhesive coverage which is greater than other typical label methods. This raises the importance of the compatibility of the type of adhesive with the recycling process. Adhesives resistant to washing in the recycling process allow labels to remain on the PET and become contaminants in the final product. Adhesives that have been found compliant with the APR test protocols should be selected.

  Two test protocols are available:
  Screening test: Thermoform Label Test
  Definitive Test: Pressure Sensitive Label Test

- Polystyrene labels require testing to determine the appropriate APR recyclability category. While PS labels are tolerated by some 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. PS inherently sinks in water due to its density so it travels with the PET in the recyclers' float-sink systems. However, expanded PS may float and in this case, it may be less of a problem to the recycler.

  One test protocol is available:
  Screening Test: Labels, Closures and Attachments Floatability Test

- Label structures that sink in water because of the choice of substrate, ink, decoration, coatings, and top layer require testing to determine the appropriate APR recyclability category. The reclaimers rely on float-sink systems to separate non-PET materials. Label components that sink with the PET end up in the RPET stream as contaminants.

  One test protocol is available:
  Definitive Test: PET Critical Guidance

- Paper labels are detrimental to recycling (for pressure sensitive paper labels reference the pressure sensitive label category). The PET reclamation process involves a hot caustic wash that removes glue and other label components to the levels required to render the RPET usable. Paper, when subjected to these conditions, becomes pulp which is very difficult to filter from the liquid, thereby adding significant load to the filtering and water treatment systems. Individual paper fibers making up pulp are very small and difficult to remove so some travel with the PET. Paper fibers remaining in the RPET carbonize when the material is heated and remelted, causing unacceptable quality degradation. Non-pulping paper labels that resist the caustic wash process sink in the float-sink tank, thereby causing RPET contamination.

- Metal foil labels are undesirable for recycling Sorting equipment in the recycling process is designed to detect and eliminate metal from PET. Even very thin metallized labels may be identified as metal by the sorting equipment and cause the entire bottle to be rejected as waste, thereby creating yield loss. If not detected, they pass through the process with the PET and cause contamination issues in the RPET.

- PVC and PLA labels render the package unrecyclable per APR. Both materials are extremely difficult to remove in the recycling process due to their similarity in density to PET. Both cause severe quality degradation in the final recycled PET stream even in very small amounts.

- Adhesives require testing to determine the appropriate APR recyclability category Adhesives that wash off cleanly from PET and remain adhered to the label are preferred. Label adhesive that is not removed from PET, or which re-deposits on the PET during the wash step is a source of contamination and discoloration when PET is recycled.

  The recycling process is designed to remove reasonably expected contamination from the surface of the PET to a degree necessary to render the RPET economically reusable in further applications. In practice,

some adhesives are resistant to this process so are detrimental to recycling. In extreme cases, an adhesive and label cannot be separated from the PET and may render a package not recyclable.

Three test protocols are available:
Screening Tests: PET Flake Wash Test and Thermoform Label Test
Definitive Test: PET Critical Guidance

- Label inks require testing to determine the appropriate APR recyclability category Some label inks bleed color in the reclamation process, discoloring the PET in contact with them and significantly diminishing 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.

  Two test protocols are available:
  Screening Tests: Bleeding Label Test and Flake to Plaque Bleeding Label Test
  *See the definitive test for the appropriate label type

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

  Three test protocols are available:
  Screening Tests: Bleeding Label Test and Flake to Plaque Bleeding Label Test
  Definitive Test: Direct Print Label Test

➢ ATTACHMENTS

- Clear PET attachments are preferred. Attachments made of the base polymer are recovered and recycled with the base polymer without causing contamination or yield loss, thereby generating the highest value.

- Tamper evident sleeves and safety seals require testing to determine the appropriate APR recyclability category. 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 material used should float and separate from the PET in the float-sink system.

  Two test protocols are available:
  Screening Test: Labels, Closures and Attachments Floatability Test
  Definitive Test: PET Critical Guidance

- Non-PET attachments such as handles require testing to determine the appropriate APR recyclability category. These should not be adhesively bonded to the package and should readily separate from the package when ground. They should be made from materials that float in water such as PP or HDPE. If adhesives are used to affix attachments, their selection should consider the adhesive criteria within this document.

  Two test protocols are available:
  Screening Test: Labels, Closures and Attachments Floatability Test
  Definitive Test: PET Critical Guidance

- Metal and metal containing attachments require testing to determine the appropriate APR recyclability category. Examples include metal foils and metalized substrates that sink in water as well as metal sprayer balls and springs. In the recycling process these items are either identified and removed along with their PET component in the early stages, thereby causing yield loss, or they pass into the recycling process causing a contamination issue. Since they are heavier than water they sink with the PET in the float-sink tank. Many of these items are too small to be removed with machinery designed to remove metal such as eddy current and optical separators. Springs in particular unravel and become entangled in filtering screens throughout the recycling process.

  One test protocol is available:
  Screening test: New Eddy Current and Magnetic Test for Attachments

- Paper attachments are detrimental to recycling. The PET reclamation process uses a hot caustic wash to remove glue and other contaminants to the levels required to render the RPET usable. Paper, when subjected to these conditions, becomes pulp which is very difficult to filter from the liquid, thereby adding significant load to the filtering and water treatment systems. Individual paper fibers making up pulp are very small and difficult to remove so some travel with the PET. Paper fibers remaining in the RPET carbonize when the material is reused causing unacceptable quality degradation.

- Welded attachments are detrimental to recycling. A certain amount of a welded attachment cannot be separated from the PET in the recycling process. These attachments, even when ground and made of floatable materials, cause RPET contamination and yield loss issues in both cases: when the PET they are attached to causes the ground section containing both polymers to sink, or when the ground section floats.

- RFID's (radio frequency identification devices) on packages, labels or closures are detrimental to recycling. 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.

- PVC and PLA attachments of any kind render the package non-recyclable per APR definition**.** The use of PVC or PLA attachments of any kind on PET packaging 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 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.

➢ BIO-BASED PET RESIN

The use of bio-based PET resin, in which the MEG component is sourced from biological materials such as sugar cane residue or similar materials, are fully compatible with petroleum-based PET in the recycling process. Bio-based PET should not be confused with PET containing bio- or oxo-degradable additives.

➢ POSTCONSUMER CONTENT

The use of postconsumer PET in all packages is encouraged to the maximum amount technically and economically feasible.

➢ RESIN IDENTIFICATION CODE, RIC

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