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” when the following three conditions are met:

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

- The item 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 design features commonly used with packaging applications. The recycling impact of each design feature is discussed within the Guide. The APR’s guidance 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, or no, negative effect on the productivity of 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 yield, productivity, 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 yield, productivity 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 compatibility with recycling, testing per an APR testing protocol is required.

**DISCLAIMER**

This document has been prepared by the Association of Plastic Recyclers as a service to the plastic industry to promote the most efficient use of the nation’s plastic recycling infrastructure and to enhance the quality and quantity of recycled postconsumer plastic. The information in this document 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. Participation in the Recognition Program is purely voluntary and does not guarantee compliance with any U.S. law or regulation or that a package or plastic article incorporating the innovation is recyclable or will be recycled.
Due to its price, clarity, chemical and UV resistance, natural barrier properties and low melting temperature, PVC is a good material for many applications. However, the low melting temperature and chemical composition of PVC makes it extremely incompatible with most other common polymers. When even minute amounts of PVC are processed with other polymers the PVC degrades into hydrochloric acid and chlorine rendering large amounts of the polymer useless. Since PVC sinks in water it is difficult to remove in conventional PET recycling systems. Currently, the number of PVC bottles in the post-consumer collected stream of plastic bottles is at such low levels that the bottles are not recycled and considered a contaminant. Because of this APR finds the use of PVC bottles undesirable if those bottles are included with bales of PET or HDPE bottles. PVC is currently best collected and recycled in a dedicated, source selected system outside the scope of the APR Design Guide for Plastics Recyclability such as a construction and demolition stream. 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:

**BASE POLYMER**

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

**BARRIER LAYERS, COATINGS & ADDITIVES**

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

*Screening Test:* TBT

Degradable additives (photo, oxo, or bio) require testing to determine the appropriate APR recyclability category. Recycled PVC 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 PVC. 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 RPVC 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 RPVC that includes the additive. These additives must either separate and be removed from the PVC in the recycling process or have no adverse effects.
on the RPVC in future uses. When used, their content should be minimized to the greatest extent possible to maximize PVC yield, limit potential contamination, and reduce separation costs.

**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 RPVC to discolor or haze after remelting since RPVC 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.

**Screening Test:** TBT

**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 RPVC 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 PVC 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.

**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.** NIR (near-infrared) sorting technology used in MRFs and reclaimers is not capable of identifying many dark polymers since the colorant absorbs light and manual sorting cannot distinguish one dark polymer from another. Some dark shades may be detected by NIR but these must be tested to determine their sortability. Other separation techniques such as float-sink cannot be employed since many polymers sink with PVC. Therefore, dark packaging is considered a contaminant for nearly all reclaimers.

**Benchmark Test:**
*Evaluation of the Near Infrared (NIR) Sorting Potential of a Whole Plastic Article* (SORT-B-01)

**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 stream; 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 require testing to determine the appropriate APR recyclability category. The industry standard screen size loses materials less than two 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 (SORT-B-02)

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. Because these polymers float, they are most easily separated from the bottle in conventional separation systems. Additionally, the PVC 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 PVC 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 RPVC stream will block extruder screens in remanufacturing. Large metal items attached to PVC 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.

**Benchmark Test:** *Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components (SORT-B-03)*

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 PVC and is difficult to remove with other methods, thereby causing contamination in the final product.

The use of PET closures or closure liners render the package non-recyclable per APR definition. PET sinks and is extremely hard for the recycler to remove.

**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 0.95 are preferred.** These materials float in water so they are separated from the PVC 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 0.95.

**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 RPVC can result in contamination.

**Definitive Test:** TBT

**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 PVC 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.

**Benchmark Test:** *Evaluation of the Near Infrared (NIR) Sorting Potential of a Whole Plastic Article (SORT-B-01)*
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.

**Screening Test:** TBT

Polystyrene labels require testing to determine the appropriate APR recyclability category. PS inherently sinks in water due to its density so it travels with the PVC 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.

**Screening Test:** *PET Package Component Sink or Float Evaluation (PET-S-05)*
(with PVC substituted for PET in the test method)

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-PVC materials. Label components that sink with the PVC end up in the RPVC stream as contaminants.

Paper labels are detrimental to recycling (for pressure sensitive paper labels reference the pressure sensitive label category).

The PVC reclamation process involves a hot caustic wash that removes glue and other label components to the levels required to render the RPVC 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 PVC. Paper fibers remaining in the RPVC 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 RPVC contamination.

Metal foil, metalized and metallic printed labels require testing to determine the appropriate recyclability category. Sorting equipment in the recycling process is designed to detect and eliminate metal from PVC. 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 PVC and cause contamination issues in the RPVC.

**Benchmark Test:** *Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components (SORT-B-03)*

PET and PETG labels render the package non-recyclable per APR definition.

This material is extremely difficult to remove in the recycling process due to its similarity in density to PVC.

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

The recycling process is designed to remove reasonably expected contamination from the surface of the PVC to a degree necessary to render the RPVC 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 PVC and may render a package not recyclable.

**Screening Tests:** TBT

**Label inks require testing to determine the appropriate APR recyclability category.** Some label inks bleed color in the reclamation process, discoloring the PVC in contact with them and significantly diminishing its value for recycling. Label inks must be chosen that do not bleed color when tested under this protocol.

**Screening Tests:** TBT

*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 RPVC is diminished. Some inks used in direct printing do not cause these problems. The specific ink must be tested to determine its effect.

**Screening Test:** TBT

**ATTACHMENTS**

Clear PVC 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 PVC in the float-sink system.

**Screening Test:** [PET Package Component Sink or Float Evaluation (PET-S-05)](http://www.PlasticsRecycling.org)
(with PVC substituted for PET in the test method)

**Non-PVC 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.
Screening Test: **PET Package Component Sink or Float Evaluation (PET-S-05)**
(with PVC substituted for PET in the test method)

Metal, metalized 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 PVC 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 PVC 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.

**Benchmark Test:** **Evaluation of Sorting Potential for Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components (SORT-B-03)**

**Paper attachments are detrimental to recycling.**
The PVC reclamation process uses a hot caustic wash to remove glue and other contaminants to the levels required to render the RPVC 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 PVC. Paper fibers remaining in the RPVC 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 PVC in the recycling process. These attachments, even when ground and made of floatable materials, cause RPVC contamination and yield loss issues in both cases: when the PVC 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 PVC 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 PVC yield, introduces potential contamination, and increases separation costs.

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

**POSTCONSUMER CONTENT**
The use of postconsumer PVC 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.