ASSOCIATION OF PLASTIC RECYCLERS

Packaging That Does Not Meet Access Requirements (PLA, PVC, EPS and PS)

At this time, PLA, PVC, EPS and PS collection systems are limited in North America so these material do not currently meet the collection accessibility criteria established in "APR's definition of recyclable" or by the Federal Trade Commission (FTC) "Green Guides". Anticipating the development and growth of recycling programs for these types of materials, however, the APR recommends the guidelines specified in this document.

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PLA (Polylactic Acid, Resin Identification Code #7)

Polylactic acid (PLA) is one of several structures and polymers using resin identification code (RIC) #7. PLA is typically used in applications requiring stiffness, resistance to cracking, clarity and ease of modification. It is easily formed into sheet and is thermoformable. PLA is often chosen as a packaging material because it is made from renewable resources and is compostable in an industrial composting facility. PLA properties can be enhanced with colorants, impact modifiers, and other additives. Each modification to base PLA must be considered for its effect on the recycling stream.

BASE POLYMER

PREFERRED

PLA and PLA resin variants which have a crystalline melting point between 140°C and 170°C

Flake from thermoformed parts, trim scrap, or cast sheet is amorphous. Flake from oriented film or oriented sheet will be a mixture of amorphous or crystalline fractions, while fibers like staple or spunbond are crystalline. Amorphous PLA flake requires drying at low temperatures (43-55°C) to prevent sticking in dryers. It is the process, the shape and degree of crystallinity, and the percentage of regrind that will determine if the recycled PLA material will need to be pre-crystallized prior to drying and melt extrusion. Recycling crystalline PLA material allows drying at temperatures in the range of 65-85°C. Non--crystallized resin and material with a lower melt point may become sticky in the reclaimer's pre-extrusion dryer and could prevent the material from flowing through the process. Contaminant materials of a higher melting point remain solid in the reclaimers' extruder, catch on and may cause blockages in melt screens and contamination in the final product.

The density of PLA is 1.24 g/cm^3 and so it sinks in water.

Recycled PLA Content

Depending on the application, a blended recipe of post-consumer and post-industrial PLA is encouraged for products up to the maximum amount technically and economically feasible.

COLOR

PREFERRED

All non-dark colors

As PLA recovery and recycling is in an early development stage and clear packaging applications are not an initial target for recycled PLA, there is a wider tolerance for pigmented polymer than if a clear packaging application was being pursued for this material. However, lighter colors will have more value and a compatibility with a wider variety of end uses.

DETRIMENTAL

See "Requires Test Results" section

REQUIRES TESTING

Black and dark colors with L-Value less than 40 or NIR reflectance less than or equal to 10%

Sortation testing for dark colors will result in either a Detrimental or a Renders Non-Recyclable ruling. Dark colors cannot be Preferred at this time.

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. Other separation techniques such as float-sink cannot be employed since many polymers sink with PLA. Therefore, dark packaging is considered a contaminant for nearly all reclaimers. Some dark shades may be detected by NIR but these must be tested to determine their sortability.

> **Test Protocol:** SORT-S-01: Evaluation of the Near Infrared (NIR) 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.

PREFERRED

Items whose dimensions are clearly more 3-dimensional than 2-dimensional

Early in the MRF sorting process, 3-dimensional items (containers) are separated from 2-dimensional items (paper). It is important that they sort property and do not cross-contaminate.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting Potential of a Whole Article

Items that clearly measure larger than 5 centimeters (two inches) in two dimensions

Small size boundaries are of concern because the industry standard screen size for Material Recovery Facilities (MRFs) in North America potentially loses materials less than two inches to the residue waste stream.

DETRIMENTAL

Items greater than 7.5 liters (2 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.

REQUIRES TESTING

Items more two-dimensional than three-dimensional

Aside from not being captured in the PLA stream, non-conforming items that are more "flat" can cause contamination in the paper stream. If items are not captured and directed into the PLA stream, they are not recycled. Items should have a minimum depth of two inches for proper sortation.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting

Potential of a Whole Article

Items smaller than 5 centimeter (2 inches) in 2 dimensions

The industry standard screen size for North American MRFs potentially loses materials less than 5 cm to the residue waste stream. Testing can determine the impact of the size and shape of a container on sortability.

Test Protocol: SORT-S-02 Evaluation of Size Sorting Potential for Articles with at least Two Dimensions less than 2 inches

CLOSURES & DISPENSERS

PREFERRED

PLA closures
Since these are the same material as the target polymer they will be recycled with it and add to the material yield.

Closures without liners made from polymers with density > 1.0g/cm^3 (specifically PE and PP)
Because these polymers float, they are most easily separated from the container in conventional separation systems. Additionally, the PLA recycling process may capture 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 that it sinks.

Closure plus liners made from polymers with density > 1.0g/cm^3 (PE, PP, EVA,TPE liners)

Because these polymers float, they are most easily separated from the container in conventional separation systems. Additionally, the PLA recycling process may capture 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 that it sinks.

Shrink film safety sleeves that are designed to be completely removed before the package can be opened
Regardless of material, designs that require complete removal by the consumer of the safety sleeve are Preferred, as the material will not be introduced into the recycling stream

DETRIMENTAL

Closures and shrink film safety sleeves made of polymers with density >1.0 that sink in water (specifically PS, silicone, nylon, acetal, thermosets)

These materials are heavier than water and sink in the float-sink tank with PLA. They are extremely difficult to separate from the recycled polymer flake, requiring a costly and inexact polymer flake sorter currently not

envisioned in the PLA reclaiming operation.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PET and PVC

PET and PVC sink in the float-sink tank with the PLA and are difficult to remove with other methods, thereby causing contamination in the final product. The recycled PLA process is very intolerable to even minute amounts of PET or PVC.

REQUIRES TESTING

Closures or lidding with metal components

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Metal contamination is highly undesirable in recycled PLA. Metals create wear in process machinery, increase operation costs and yield loss, and are a primary source of defects in products made with recycled PLA. MRFs and PLA reclaimers use magnets and metal detectors to keep packages with metal components out of the process stream. Metal components such as closures or lidding that trigger metal detectors will cause the entire plastic item to be removed from the stream and not recycled. At best, sortation testing will classify such an item as Detrimental to Recycling.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Shrink film safety sleeves that are NOT designed to be completely removed before the package can be opened

If a shrink film safety sleeve is designed such that pieces of it may not detach from the package when opened, the material must be tested to determine its compatibility with PLA recycling. Specifically, such materials should either float and be separated from the PLA, or if they sink, they must be compatible with PLA. Companies that are considering such sleeves and are unsure of their compatibility with recycling should ask their suppliers to provide APR test results.

No test methods currently exist for PLA. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PLA for PET.

> **Testing Protocol:** PET-S-05 PET Package Component Sink/Float Evaluation

Closure valves containing silicone (density and floatability will vary)

Check valves in spray dispensers or pumps may be made of silicone as an alternative to metals. While polymers are generally preferable to metals, the composition of a silicone part may cause it to be incompatible with PLA recycling. It should float in the sink/float system. Companies that are considering such components and are unsure of their compatibility with recycling should ask their suppliers to provide APR test results.

No test methods currently exist for PLA. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PLA for PET.

> **Testing Protocol:** PET-S-05 PET Package Component Sink/Float Evaluation

Closures, dispenser valves, or springs made of metal

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Metal is difficult to separate from PLA 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 recycled polymer stream will block extruder screens in remanufacturing. Large metal items attached to PLA 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.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

LABELS, INKS AND ADHESIVES

Label selection should be considered carefully to find the solution most compatible with the recycling process that also provides the necessary performance characteristics. At a minimum, labels must be designed so NIR sorting machinery can identify the bottle polymer with the label attached, and labels should use adhesives that release from the bottle. Removing adhesives is a significant component to the cost of recycling so the packages using the lowest quantity of appropriate adhesive are the most compatible.

PREFERRED

PLA labels
Since these are the same material as the target polymer they will be recycled with it and add to the material yield.

Polymers with a density < 1.0 that float in water, specifically polypropylene or polyethylene

If a PLA label is not available or suitable, then PP or PE labels are preferred since they float in water and separated from the PLA 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 g/cm^3. Minimizing label size is advantageous to both processes.

DETRIMENTAL

Paper labels are detrimental to recycling.
The PLA reclamation process may involve a wash that removes glue and other label components to the levels required to render the RPLA 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 PLA. Paper fibers remaining in the RPLA carbonize when the material is heated and re-melted, causing quality degradation and a burnt smell to the polymer. Paper fibers could also cause quality issues, such as non-melted particles in the melt stream and final article. Non-pulping paper labels that resist the wash process sink in the float-sink tank, thereby causing RPLA contamination. These, although removed when the polymer is melt filtered, carbonize causing the same effect. (For pressure sensitive paper labels reference the pressure sensitive label category).

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PET and PETG

Both materials are extremely difficult to remove in the recycling process due to their similarity in density to PLA which causes them to sink in the float/sink tank along with the PLA. Both cause severe quality degradation in the final recycled PLA stream even in very small amounts.

PVC

This material is extremely difficult to remove in the recycling process due to its similarity in density to PLA. The recycled PLA process is very intolerant of even minute amounts of PVC.

REQUIRES TESTING

Laminated label substrate
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 recycled PLA can result in contamination.

Test: *TBD*

Full container sleeve labels

Full container sleeve labels cover a large amount of the container surface with a polymer that is not the same as the container body. Because of this, a sleeve label designed without considering recycling may cause a false reading on an automatic sorter and direct a PLA container 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 RPLA produced. Sleeve labels that have been found compliant with the APR test protocols should be selected.

Test Protocol: SORT-S-01: Evaluation of the Near Infrared (NIR) Sorting Potential of a Whole Plastic Article

Metal foil, metalized and metallic printed labels

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Sorting equipment in the recycling process is designed to detect and eliminate metal from PLA. Even very thin metallized labels may be identified as metal by the sorting equipment and cause the entire package to be rejected as waste, thereby creating yield loss. If not detected, they pass through the process with the PLA and cause contamination issues in the final product.

Testing Protocol: SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Pressure sensitive labels and adhesives

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 container and become contaminants in the final product. Adhesives that have been found compliant with the APR test protocols should be selected.

Testing Protocol: *TBD*

Direct printing other than date coding

Historically, inks used in direct printing tend to bleed or otherwise discolor the polymer during the recycling process or introduce incompatible contaminants. In either case, the value of the recycled polymer may be diminished. Some inks used in direct printing do not cause these problems. The specific ink must be tested to determine its effect.

No test methods currently exist for PLA. However, HDPE Bleeding Label Test (HDPE-S-01) may be adapted substituting PLA for HDPE.

Testing Protocol: HDPE-S-01 Natural HDPE Flake Wash

Label adhesives

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

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

Testing Protocol: *TBD*

Label Inks

Some label inks bleed color in the reclamation process, discoloring the polymer 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.

Testing Protocol: *TBD*

BARRIER LAYERS, COATINGS & ADDITIVES

Barrier layers, coatings, and other additives may be added to PLA bottles and containers to enhance the properties of PLA. Unlike closures or labels, these additions cannot be visually determined to be problematic or potentially problematic for recycling. Therefore, testing is particularly important. APR promotes innovation in the development of new barrier technologies that can be demonstrated by testing to be compatible with recycling.

PREFERRED

See "Requires Test Results" section

DETRIMENTAL

Optical brighteners

Like many other additives, optical brighteners are not removed in the recycling process and can create an unacceptable fluorescence for next uses of the recycled polymer 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.

Also see "Requires Test Results" Section

REQUIRES TESTING

Other barrier materials, additives or coatings

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 polymer to discolor or haze after remelting since recycled material 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.

Test protocol: TBD

ATTACHMENTS

PREFERRED

PLA attachments

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.

DETRIMENTAL

Paper attachments
The PLA reclamation process may use a wash to remove glue and other contaminants to the levels required to render the RPLA 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 final polymer. Paper fibers remaining in the RPLA carbonize when the material is reused causing quality degradation.

Welded attachments
A certain amount of a welded attachment cannot be separated from the main polymer in the recycling process.

These attachments, even when ground and made of floatable materials, cause contamination and yield loss issues in both cases: when the PLA 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
Unless they are compatible with PLA 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 yield, introduces potential contamination, and increases separation costs.

RENDERS NON-RECYCLABLE

PET and PVC attachments

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

REQUIRES TESTING

Metal and metal containing attachments

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Examples include metal foils and metalized substrates that sink in water. In the recycling process these items are either identified and removed along with their PLA 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 PLA in the float-sink tank.

If a metalized attachment causes the PLA bottle to fail sortation testing, the bottle is Rendered Non-Recyclable as it is removed from the stream and discarded. If a metalized attachment passes through sortation, it is considered Detrimental as it contaminates PLA.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

PVC (Polyvinyl Chloride, Resin Identification Code #3)

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. PVC sinks in water and is therefore 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.

BASE POLYMER

PREFERRED

Recycled PVC Content

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

COLOR

PREFERRED

Clear unpigmented polymer

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

DETRIMENTAL

See "Requires Test Results" section

REQUIRES TESTING

Black and dark colors with L-Value less than 40 or NIR reflectance less than or equal to 10%

Sortation testing for dark colors will result in either a Detrimental or a Renders Non-Recyclable ruling. Dark colors cannot be Preferred at this time.

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. 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. Some dark shades may be detected by NIR but these must be tested to determine their sortability.

> **Test Protocol:** SORT-S-01: Evaluation of the Near Infrared (NIR) 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.

PREFERRED

Items whose dimensions are clearly more 3-dimensional than 2-dimensional

Early in the MRF sorting process, 3-dimensional items (containers) are separated from 2-dimensional items (paper). It is important that they sort property and do not cross-contaminate.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting Potential of a Whole Article

Items that clearly measure larger than 5 centimeters (two inches) in two dimensions

Small size boundaries are of concern because the industry standard screen size for Material Recovery Facilities (MRFs) in North America potentially loses materials less than two inches to the residue waste stream.

DETRIMENTAL

Items greater than 7.5 liters (2 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 including PVC either negatively affect or are lost by the polyethylene processing.

REQUIRES TESTING

Items more two-dimensional than three-dimensional

Aside from not being captured in the PVC stream, non-conforming items that are more "flat" can cause contamination in the paper stream. If items are not captured and directed into the PVC stream, they are not recycled. Items should have a minimum depth of two inches for proper sortation.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting Potential of a Whole Article

Items smaller than 5 centimeter (2 inches) in 2 dimensions

The industry standard screen size for North American MRFs potentially loses materials less than 5 cm to the residue waste stream. Testing can determine the impact of the size and shape of a container on sortability.

> **Test Protocol:** SORT-S-02 Evaluation of Size Sorting Potential for Articles with at least Two Dimensions less than 2 inches

CLOSURES & DISPENSERS

PREFERRED

Closures without liners made from polymers with density > 1.0 g/cm^3 (specifically PE and PP)

Because these polymers float, they are most easily separated from the container in conventional separation systems. Additionally, the PVC recycling process may capture 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 that it sinks. ote that these sinking polymers are not removed in the combined recycling process but instead become a contaminate. Minimizing closure size is advantageous to both processes.

Closure plus liners made from polymers with density > 1.0 g/cm^3 (PE, PP, EVA,TPE liners)

Shrink film safety sleeves of polymers with density < 1.0 g/cm^3 that float in water

Shrink film safety sleeves that are designed to be completely removed before the package can be opened
Regardless of material, designs that require complete removal by the consumer of the safety sleeve are Preferred, as the material will not be introduced into the recycling stream

DETRIMENTAL

Closure liners that are composites of aluminum and paper

These materials will contaminate wash water, will contribute to waste disposal costs, or will stick to the saleable closure material or valuable PVC and reduce quality and value of the final products.

Closures and shrink film safety sleeves made of polymers with density >1.0 that sink in water (specifically PS, silicone, nylon, acetal, thermosets)

These materials are heavier than water and sink in the float-sink tank with PLA. They are extremely difficult to separate from the recycled polymer flake, requiring a costly and inexact polymer flake sorter currently not envisioned in the PLA reclaiming operation.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PET

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

REQUIRES TESTING

Closures or lidding with metal components

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Metal contamination is highly undesirable in recycled PLA. Metals create wear in process machinery, increase operation costs and yield loss, and are a primary source of defects in products made with recycled PVC. MRFs and PVC reclaimers use magnets and metal detectors to keep packages with metal components out of the process stream. Metal components such as closures or lidding that trigger metal detectors will cause the entire plastic item to be removed from the stream and not recycled. At best, sortation testing will classify such an item as Detrimental to Recycling.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Shrink film safety sleeves that are NOT designed to be completely removed before the package can be opened

If a shrink film safety sleeve is designed such that pieces of it may not detach from the package when opened, the material must be tested to determine its compatibility with PVC recycling. Specifically, such materials should either float and be separated from the PVC, or if they sink, they must be compatible with PVC. Companies that are considering such sleeves and are unsure of their compatibility with recycling should ask their suppliers to provide APR test results.

No test methods currently exist for PVC. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PVC for PET.

> **Testing Protocol:** PET-S-05 PET Package Component Sink/Float Evaluation

Closure valves containing silicone (density and floatability will vary)

Check valves in spray dispensers or pumps may be made of silicone as an alternative to metals. While polymers are generally preferable to metals, the composition of a silicone part may cause it to be incompatible with PVC recycling. It should float in the sink/float system. Companies that are considering such components and are unsure of their compatibility with recycling should ask their suppliers to provide APR test results.

No test methods currently exist for PVC. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PVC for PET.

> **Testing Protocol:** PET-S-05 PET Package Component Sink/Float Evaluation

Closures, dispenser valves, or springs made of metal

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

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 recycled polymer 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.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

LABELS, INKS AND ADHESIVES

Label selection should be considered carefully to find the solution most compatible with the recycling process that also provides the necessary performance characteristics. At a minimum, labels must be designed so NIR sorting machinery can identify the bottle polymer with the label attached, and labels should use adhesives that release from the bottle. Removing adhesives is a significant component to the cost of recycling so the packages using the lowest quantity of appropriate adhesive are the most compatible.

PREFERRED

Polymers with a density < 1.0 g/cm^3 that float in water, specifically polypropylene or polyethylene

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. Note that these are not removed in the combined recycling process but, instead become contaminates. Minimizing label size is advantageous to both processes.

DETRIMENTAL

Paper labels

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 re-melted, causing quality degradation and a burnt smell to the polymer. Non-pulping paper labels that resist the caustic wash process sink in the float-sink tank, thereby causing RPVC contamination. These, although removed when the polymer is melt filtered, carbonize causing the same effect.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PET and PETG

Both materials are extremely difficult to remove in the recycling process due to their similarity in density to PVC which causes them to sink in the float/sink tank along with the PVC. Both cause severe quality degradation in the final recycled PVC stream even in very small amounts.

REQUIRES TESTING

Laminated label substrate
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 recycled PVC can result in contamination.

> **Test:** *TBD*

Full container sleeve labels

Full container sleeve labels cover a large amount of the container surface with a polymer that is not the same as the container body. Because of this, a sleeve label designed without considering recycling may cause a false reading on an automatic sorter and direct a PVC container 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 recycled PVC produced. Sleeve labels that have been found compliant with the APR test protocols should be selected.

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

Metal foil, metalized and metallic printed labels

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

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 package 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 final product.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Label structures that sink in water because of the choice of substrate, ink, decoration, coatings, and top layer

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. No test methods currently exist for PVC. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PVC for PET.

No test methods currently exist for PVC. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PVC for PET.

Testing Protocol: PET-S-05 PET Package Component Sink/Float Evaluation

Pressure sensitive labels and adhesives

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 container and become contaminants in the final product. Adhesives that have been found compliant with the APR test protocols should be selected.

Testing Protocol: *TBD*

Polystyrene labels

PS inherently sinks in water due to its density and so it therefore travels with the PVC in the recyclers' float-sink systems. However, Expanded PS (EPS) may float and in this case, it may be less of a problem to the recycler.

No test methods currently exist for PVC. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PVC for PET.

Testing Protocol: PET-S-05 PET Package Component Sink/Float Evaluation

Direct printing other than date coding

Historically, inks used in direct printing tend to bleed or otherwise discolor the polymer during the recycling process or introduce incompatible contaminants. In either case, the value of the recycled polymer may be diminished. Some inks used in direct printing do not cause these problems. The specific ink must be tested to determine its effect.

No test methods currently exist for PVC. However, HDPE Bleeding Label Test (HDPE-S-01) may be adapted substituting PVC for HDPE.

Testing Protocol: HDPE-S-01 Natural HDPE Flake Wash

Label adhesives

Adhesives that wash off cleanly from PVC and remain adhered to the label are preferred. Label adhesive that is not removed from PVC, 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 container to a degree necessary to render the polymer 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.

Testing Protocol: *TBD*

Label Inks

Some label inks bleed color in the reclamation process, discoloring the polymer 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.

Testing Protocol: *TBD*

BARRIER LAYERS, COATINGS & ADDITIVES

Barrier layers, coatings, and other additives may be added to PVC bottles and containers to enhance the properties of PVC. Unlike closures or labels, these additions cannot be visually determined to be problematic or potentially problematic for recycling. Therefore, testing is particularly important. APR promotes innovation in the development and testing of new barrier technologies that can be demonstrated by testing to be compatible with recycling.

PREFERRED

None Specified

DETRIMENTAL

Optical brighteners

Like many other additives, optical brighteners are not removed in the recycling process and can create an unacceptable fluorescence for next uses of the recycled polymer 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.

Untested barrier materials or additives for product protection
Barriers and additives that have not been tested under APR test protocols are classified as Detrimental due to a

lack of data about their impact on the cost, productivity and quality of the PVC recycling process. Companies must test as explained below.

Also see "Requires Test Results" Section

REQUIRES TESTING

Barrier materials, additives or coatings for product protection

Barriers and additives that have not been tested under APR test protocols are classified as Detrimental due to a lack of data about their impact on the cost, productivity and quality of the PVC recycling process. Companies must test as explained below.

Test protocol: TBD

Other barrier materials, additives or coatings

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 polymer to discolor or haze after remelting since recycled material 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.

Test protocol: TBD

Degradable additives (photo, oxo, or bio)

Recycled PVC is intended to be used in new products engineered to meet particular quality and durability standards. Additives designed to degrade the polymer diminish the life of the material in the primary use and may shorten the useful life of the product made from the rPVC as well, possibly compromising quality and durability. 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.

Test protocol: TBD

ATTACHMENTS

PREFERRED

Clear PVC attachments

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.

DETRIMENTAL

Paper attachments

The PVC reclamation process may use a 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 final polymer. Paper fibers remaining in the RPVC carbonize when the material is reused causing quality degradation.

Welded attachments

A certain amount of a welded attachment cannot be separated from the main polymer in the recycling process. These attachments, even when ground and made of floatable materials, cause 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

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 yield, introduces potential contamination, and increases separation costs.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PET and PLA attachments

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 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.

REQUIRES TESTING

Metal and metal containing attachments

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Examples include metal foils and metalized substrates that sink in water. 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.

If a metalized attachment causes the PVC bottle to fail sortation testing, the bottle is Rendered Non-Recyclable as it is removed from the stream and discarded. If a metalized attachment passes through sortation, it is considered Detrimental as it contaminates PVC.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential of Plastic Articles Utilizing Metal, Metalized or Metallic Printed Components

Non-PVC attachments such as handles

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.

No test methods currently exist for PVC. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PVC for PET.

> **Testing Protocol:** PET-S-05 PET Package Component Sink/Float Evaluation

PS (Polystyrene) and EPS (Expanded Polystyrene),

Resin Identification Code #6

Rigid polystyrene (PS) is typically used in applications requiring its stiffness, resistance to cracking, and ease of modification.

The light bulk density of expanded polystyrene (EPS) provides outstanding insulation and cushioning and is frequently used in applications requiring these properties. EPS is most often collected and recycled in a dedicated, source selected system outside the scope of the APR Design Guide for Plastics Recyclability such as a distribution center stream. EPS is a very recyclable material once the product arrives at the reclaimer. Collection and transportation challenges should not be confused with processability and reusability of this material.

Anticipating the development and growth of future PS and EPS recycling programs, the APR encourages suppliers to use the design guidelines in this document.

RIGID POLYSTYRENE (PS)

BASE POLYMER

PREFERRED

Recycled PS (rPS) Content
The use of postconsumer PS in all packages and items is encouraged to the maximum amount technically and economically feasible.

DETRIMENTAL

None listed

RENDERS NON-RECYCLABLE

None listed

REQUIRES TEST RESULTS

Blends of PS and other resins designed to enhance properties in the intended first use with unknown residual effects in future uses of the recovered resin. No test methods currently exist for PS. However, Critical Guidance Protocol for Clear PET Resins and Molded Articles (PET-CG-01) may be adapted, substituting PS for PET and using ambient temperature water with no detergent.

Testing Protocol: PET-CG-01 Critical Guidance Protocol for Clear PET Resins and Molded Articles

COLOR

PREFERRED

Clear unpigmented polymer

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.

DETRIMENTAL

See “Requires Test Results” section

REQUIRES TEST RESULTS

Black and dark colors with L-Value less than 40 or NIR reflectance less than 10%

Sortation testing for dark colors will result in either a Detrimental or a Renders Non-Recyclable ruling. Dark colors cannot be Preferred at this time.

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. Other separation techniques such as float-sink cannot be employed since many polymers sink with PS. Therefore, dark packaging is considered a contaminant for nearly all reclaimers. Some dark shades may be detected by NIR but these must be tested to determine their sortability.

> **Testing Protocol**: SORT-S-01 Evaluation of the Near Infrared (NIR) 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.

PREFERRED

Items whose dimensions are clearly more 3-dimensional than 2-dimensional

Early in the MRF sorting process, 3-dimensional items (containers) are separated from 2-dimensional items (paper). It is important that they sort property and do not cross-contaminate.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting Potential of a Whole Article

Items that clearly measure larger than 5 centimeters (two inches) in two dimensions

Small size boundaries are of concern because the industry standard screen size for Material Recovery Facilities (MRFs) in North America potentially loses materials less than two inches to the residue waste stream.

DETRIMENTAL

Items greater than 7.5 liters (2 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 including PS either negatively affect or are lost by the polyethylene processing.

REQUIRES TESTING

Items more two-dimensional than three-dimensional

Aside from not being captured in the PS stream, non-conforming items that are more "flat" can cause contamination in the paper stream. If items are not captured and directed into the PS stream, they are not recycled. Items should have a minimum depth of two inches for proper sortation.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting Potential of a Whole Article

Items smaller than 5 centimeter (2 inches) in 2 dimensions

The industry standard screen size for North American MRFs potentially loses materials less than 5 cm to the residue waste stream. Testing can determine the impact of the size and shape of a container on sortability.

> **Test Protocol:** SORT-S-02 Evaluation of Size Sorting Potential for Articles with at least Two Dimensions less than 2 inches

CLOSURES, SPRAY DISPENSERS, AND PUMPS

CLOSURE, CLOSURE LINERS & SAFETY SEALS

PREFERRED

Closures without liners, made from polymers with density <1.0 g/cm^3 that float in water
Floating polymers are most easily separated from rigid polystyrene in conventional separation systems. 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. Note that these sinking polymers are not removed in the combined recycling process but, instead become a contaminate. Minimizing closure size is advantageous to both processes.

Closures plus liners made from polymers with density < 1.0 g/cm^3 that float in water (specifically PE & PP closures; PE foam, EVA, TPE liners)

Shrink film safety sleeves of polymers with density < 1.0 g/cm^3 that float in water
Shrink film safety sleeves that are designed to be completely removed before the package can be opened
Regardless of material, designs that require complete removal by the consumer of the safety sleeve are Preferred, as the material will not be introduced into the recycling stream.

DETRIMENTAL

Closure liners that are composites of aluminum and paper

These materials will contaminate wash water, will contribute to waste disposal costs, or will stick to the saleable closure material or valuable PS and reduce quality and value of the final products.

Closures and shrink film safety sleeves made of polymers with density >1.0 g/cm^3 that sink in water (specifically PS, silicone, nylon, acetal, thermosets)

These materials are heavier than water and sink in the float-sink tank with rigid PS. They are extremely difficult to separate from the recycled polymer flake, requiring a costly and inexact polymer flake sorter currently not installed in many reclaiming operations.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PVC

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

REQUIRES TEST RESULTS

Closures or lidding with metal components

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Metal contamination is highly undesirable in recycled PS. Metals create wear in process machinery, increase operation costs and yield loss, and are a primary source of defects in products made with recycled PS. MRFs and PS reclaimers use magnets, eddy current separators and metal detectors to keep packages with metal components out of the process stream. Metal components such as closures or lidding that trigger metal detectors will cause the entire plastic item to be removed from the stream and not recycled. At best, sortation testing will classify such an item as Detrimental to Recycling**.**

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential for Plastic Articles Utilizing Metal; Metalized or Metallic Printed Components

Shrink film safety sleeves that are NOT designed to be completely removed before the package can be opened

If a shrink film safety sleeve is designed such that pieces of it may not detach from the package when opened, the material must be tested to determine its compatibility with PS recycling. Specifically, such materials should either float and be separated from the PS, or if they sink, they must be compatible with PS. Companies that are considering such sleeves and are unsure of their compatibility with recycling should ask their suppliers to provide APR test results.

No test methods currently exist for PS. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PS for PET.

Testing Protocol: PET-S-05 PET Package Component Sink/Float Evaluation
PET-CG-02 Critical Guidance Protocol for Clear PET Articles with Labels and Closures

SPRAY DISPENSERS AND PUMPS

PREFERRED

Polymers with density < 1.0 g/cm^3 that float in water *(specifically PE & PP closures; PE foam, EVA, TPE liners)*
The density of PS is 1.05 g/cm^3 and so it sinks in water. Since these other polymers float in water, they are most easily separated from rigid PS flake in conventional separation systems. Care must be taken when modifying the PE or PP, with mineral fillers for example, to ensure the modifier does not increase the overall density to the point it sinks.

DETRIMENTAL

See "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PVC
The use of PVC in closures, liners, spray dispensers or pumps renders the package non-recyclable per APR. PVC sinks and is extremely hard for the recycler to remove, particularly in small pieces. The recycled PS stream is very intolerant of even minute amounts of PVC.

REQUIRES TEST RESULTS

Valves containing silicone (density and floatability will vary)

Check valves in spray dispensers or pumps may be made of silicone as an alternative to metals. While polymers are generally preferable to metals, the composition of a silicone part may cause it to be incompatible with PS recycling. It should float in the sink/float system or be compatible with PS if it sinks. Companies that are considering such components and are unsure of their compatibility with recycling should ask their suppliers to provide APR test results. No test methods currently exist for PS. However, PET Package Component Sink/Float

Evaluation (PET-S-05) may be adapted substituting PS for PET. No test methods currently exist for PS. However, Critical Guidance Protocol for Clear PET Articles with Labels and Closures (PET-CG-02) may be adapted, substituting PS for PET, using ambient temperature water with no detergent

Testing Protocol: PET-S-05 PET Package Component Sink/Float Evaluation
PET-CG-02 Critical Guidance Protocol for Clear PET Articles with Labels and Closures

Closures, dispenser valves, or springs made of metal

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time. Metal is difficult to separate from PS 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 recycled polymer stream will block extruder screens in remanufacturing. Large metal items attached to PS 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.

Testing Protocol: SORT-S-03 Evaluation of Sorting Potential for Plastic Articles Utilizing Metal; Metalized or Metallic Printed Components

BARRIER LAYERS, COATINGS & ADDITIVES

Barrier layers, coatings, and other additives may be added to PS bottles and containers to enhance the properties of PS. Unlike closures or labels, these additions cannot be visually determined to be problematic or potentially problematic for recycling. Therefore, testing is particularly important.

APR promotes innovation in the development and testing of new barrier technologies that can be demonstrated by testing to be compatible with recycling.

PREFERRED

None specified

DETRIMENTAL

Optical brighteners

Like many other additives, optical brighteners are not removed in the recycling process and can create an unacceptable fluorescence for next uses of the recycled polymer 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.

Untested barrier materials or additives for product protection

Barriers and additives that have not been tested under APR test protocols are classified as Detrimental due to a lack of data about their impact on the cost, productivity and quality of the PS recycling process. Companies must test as explained below.

Also see "Requires Test Results" Section

REQUIRES TEST RESULTS

Barrier materials, additives or coatings for product protection

Barriers and additives that have not been tested under APR test protocols are classified as Detrimental due to a lack of data about their impact on the cost, productivity and quality of the PS recycling process. Companies must test as explained below.

Testing protocol: TBD

Other barrier materials, additives or coatings

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 polymer to discolor or haze after remelting since recycled material 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.

Testing protocol: TBD

Degradable additives (photo, oxo, or bio)

Recycled PS is intended to be used in new products engineered to meet particular quality and durability standards. Additives designed to degrade the polymer diminish the life of the material in the primary use, and may shorten the useful life of the product made from the rPS as well, possibly compromising quality and durability. These additives must either separate and be removed from the PS in the recycling process or have no adverse effects on the rPS in future uses. When used, their content should be minimized to the greatest extent possible to maximize PS yield, limit potential contamination, and reduce separation costs.

Testing protocol: TBD

LABELS, INKS AND ADHESIVES

Label selection should be considered carefully to find the solution most compatible with the recycling process that also provides the necessary performance characteristics. At a minimum, labels must be designed so NIR sorting machinery can identify the bottle polymer with the label attached, and labels should use adhesives that release from the bottle. Removing adhesives is a significant component to the cost of recycling so the packages using the lowest quantity of appropriate adhesive are the most compatible.

PREFERRED

Polymer labels with a density < 1.0 that float in water, specifically polypropylene or polyethylene

These materials float in water so they are separated from the rigid PS 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. Note that these are not removed in the combined recycling process but, instead become a contaminate. Minimizing label size is advantageous to both processes.

Polystyrene labels

PS is the same material as the bottle body, so the label will behave like the bottle, and be recycled along with it.

High melting temperature plastic labels such as PET

These labels sink in the float sink tank if one is employed and remain solid in the PS extruder so they can be removed through filtering.

DETRIMENTAL

Paper labels

The PS reclamation process involves a wash that removes glue and other label components to the levels required to render the RPS 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 PS. Paper fibers remaining in the RPS carbonize when the material is heated and re-melted, causing quality degradation and a burnt smell to the polymer. Non-pulping paper labels that resist the caustic wash process sink in the float-sink tank, thereby causing RPS contamination. These, although removed when the polymer is melt filtered, carbonize causing the same effect.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PVC and PLA

Both materials are extremely difficult to remove in the recycling process due to their similarity in density to PS which causes them to sink in the float/sink tank along with the PS. Both cause severe quality degradation in the final recycled PS stream even in very small amounts.

REQUIRES TEST RESULTS

Laminated label substrate

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 RPS can result in contamination.

> **Testing Protocol**: TBD

Full bottle sleeve labels

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 PS 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 RPS produced. Sleeve labels that have been found compliant with the APR test protocols should be selected.

> **Testing Protocl**: SORT-S-01 Evaluation of the Near Infrared (NIR) Sorting Potential of a Whole Plastic Article

Metal foil, metalized and metallic printed labels

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Sorting equipment in the recycling process is designed to detect and eliminate metal from PS. 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 PS and cause contamination issues in the final product.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential for Plastic Articles Utilizing Metal; Metalized or Metallic Printed Components

Label structures that sink in water because of the choice of substrate, ink, decoration, coatings, and top layer

The reclaimers rely on float-sink systems to separate non-PS materials. Label components that sink with the PS end up in the RPS stream as contaminants. No test methods currently exist for PS. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PS for PET.

Testing Protocol: PET-S-05 PET Packaging Component Sink or Float Evaluation

Pressure sensitive labels and adhesives

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 container and become contaminants in the final product. Adhesives that have been found compliant with the APR test protocols should be selected.

Testing Protocol: TBD

Direct printing other than date coding

Historically, inks used in direct printing tend to bleed or otherwise discolor the polymer during the recycling process or introduce incompatible contaminants. In either case, the value of the recycled polymer is diminished. Some inks used in direct printing do not cause these problems. The specific ink must be tested to determine its effect. No test methods currently exist for PS. However, HDPE Bleeding Label Test (HDPE-S-01) may be adapted substituting PS for HDPE.

Testing Protocol: HDPE-S-01 Natural HDPE Flake Wash Test

REQUIRES TEST RESULTS

Label adhesives

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

The recycling process is designed to remove reasonably expected contamination from the surface of the container to a degree necessary to render the polymer 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 PS/PLA and may render a package not recyclable.

Testing Protocol: TBD

Label Inks

Some label inks bleed color in the reclamation process, discoloring the polymer 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.

Testing Protocol: TBD

ATTACHMENTS

PREFERRED

Clear PS attachments

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.

DETRIMENTAL

Paper attachments

The PS reclamation process uses a wash to remove glue and other contaminants to the levels required to render the RPS 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 final polymer. Paper fibers remaining in the RPS carbonize when the material is reused causing quality degradation.

Welded attachments

A certain amount of a welded attachment cannot be separated from the main polymer in the recycling process. These attachments, even when ground and made of floatable materials, cause contamination and yield loss issues in both cases: when the PS 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

Unless they are compatible with PS 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 yield, introduces potential contamination, and increases separation costs.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

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

REQUIRES TEST RESULTS

Metal, metalized and metal containing attachments

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Examples include metal foils and metalized substrates that sink in water. In the recycling process these items are either identified and removed along with their PS 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 PS in the float-sink tank.

If a metalized attachment causes the PS bottle to fail sortation testing, the bottle is Rendered Non-Recyclable as it is removed from the stream and discarded. If a metalized attachments passes through sortation, it is considered Detrimental as it contaminates PS.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential for Plastic Articles Utilizing Metal; Metalized or Metallic Printed Components

Non-PS attachments such as handles

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. No test methods currently exist for PS. However, PET Package Component Sink/Float Evaluation (PET-S-05) may be adapted substituting PS for PET

> **Testing Protocol**: PET-S-05 PET Packaging Component Sink or Float Evaluation

EXPANDED POLYSTYRENE (EPS)

BASE POLYMER

PREFERRED

Recycled EPS (rEPS) Content

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

DETRIMENTAL

None listed

RENDERS NON-RECYCLABLE

None listed

REQUIRES TEST RESULTS

None listed

COLOR

PREFERRED

Unpigmented or white polymer

Unpigmented or white 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.

Light pink or light blue

These colors are common and dilute enough that they don't significantly affect the color of the recycled product.

DETRIMENTAL

See "Requires Test Results" section

RENDERS NON-RECYCLABLE

See "Requires Test Results" section

REQUIRES TEST RESULTS

Black and dark colors with L-Value less than 40 or NIR reflectance less than 10%

Sortation testing for dark colors will result in either a Detrimental or a Renders Non-Recyclable ruling. Dark colors cannot be Preferred at this time.

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. Therefore, dark packaging is considered a contaminant for nearly all reclaimers. Some dark shades may be detected by NIR but these must be tested to determine their sortability.

> **Testing Protocol**: SORT-S-01 Evaluation of the Near Infrared (NIR) 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.

PREFERRED

Items whose dimensions are clearly more 3-dimensional than 2-dimensional

Early in the MRF sorting process, 3-dimensional items (containers) are separated from 2-dimensional items (paper). It is important that they sort property and do not cross-contaminate.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting Potential of a Whole Article

Items that clearly measure larger than 5 centimeters (two inches) in two dimensions

Small size boundaries are of concern because the industry standard screen size for Material Recovery Facilities (MRFs) in North America potentially loses materials less than two inches to the residue waste stream.

DETRIMENTAL

Items greater than 7.5 liters (2 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 including PS either negatively affect or are lost by the polyethylene processing.

REQUIRES TESTING

Items more two-dimensional than three-dimensional

Aside from not being captured in the EPS stream, non-conforming items that are more "flat" can cause contamination in the paper stream. If items are not captured and directed into the EPS stream, they are not recycled. Items should have a minimum depth of two inches for proper sortation.

> **Test Protocol:** SORT-S-05 Evaluation of the Two Dimensional/Three Dimensional (2D3D) Sorting Potential of a Whole Article

Items smaller than 5 centimeter (2 inches) in 2 dimensions

The industry standard screen size for North American MRFs potentially loses materials less than 5 cm to the residue waste stream. Testing can determine the impact of the size and shape of a container on sortability.

> **Test Protocol:** SORT-S-02 Evaluation of Size Sorting Potential for Articles with at least Two Dimensions less than 2 inches

CLOSURES, SPRAY DISPENSERS, AND PUMPS

PREFERRED

Shrink film safety sleeves that are designed to be completely removed before the package can be opened

Regardless of material, designs that require complete removal by the consumer of the safety sleeve are Preferred, as the material will not be introduced into the recycling stream.

DETRIMENTAL

Polypropylene and polyethylene closures

Although the polymer is heavier than water, EPS floats in water due to the air entrapped in the structure. PE and PP float as well so they are not separated by conventional density separation methods. PE and PP therefore, remain with the EPS until the extrusion process. Contaminates that remain until the extrusion process are filtered from the PS if they remain solid at PS processing temperatures. PE and PP are liquid at these temperatures and are not removed.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PVC

Float sink tanks are not perfect machines. Even though PVC sinks and the EPS floats small amounts of PVC travel with the EPS. The recycled EPS stream is very intolerable to even minute amounts of PVC since it degrades quickly at EPS processing temperatures, erodes machinery and creates a safety risk. Small pieces of PVC render large amounts of the finished product unusable.

Also see "Requires Test Results" Section

REQUIRES TEST RESULTS

Closures or lidding with metal components

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time.

Metal contamination is highly undesirable in recycled EPS. Metals create wear in process machinery, increase operation costs and yield loss, and are a primary source of defects in products made with recycled EPS. MRFs and EPS reclaimers use magnets, eddy current separators and metal detectors to keep packages with metal components out of the process stream. Metal components such as closures or lidding that trigger metal detectors will cause the entire plastic item to be removed from the stream and not recycled. At best, sortation testing will classify such an item as Detrimental to Recycling**.**

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential for Plastic Articles Utilizing Metal; Metalized or Metallic Printed Components

BARRIER LAYERS, COATINGS & ADDITIVES

APR promotes innovation in the development and testing of new barrier technologies that can be demonstrated by testing to be compatible with recycling.

PREFERRED

None specified

DETRIMENTAL

Halogenated fire retardants

These materials are frequently used in EPS boards and molded shapes designed for insulation. Minute amounts can have a significant impact on the melt flow of the reprocessed resin.

Also see "Requires Test Results" Section

REQUIRES TEST RESULTS

Degradable additives (photo, oxo, or bio)
Recycled EPS is intended to be used in new products engineered to meet particular quality and durability standards. Additives designed to degrade the polymer diminish the life of the material in the primary use, and may shorten the useful life of the product made from the rEPS as well, possibly compromising quality and durability. These additives must either separate and be removed from the EPS in the recycling process or have no adverse effects on the rEPS in future uses. When used, their content should be minimized to the greatest extent possible to maximize EPS yield, limit potential contamination, and reduce separation costs.

Testing protocol: TBD

Other barrier materials, additives or coatings

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 polymer to discolor or haze after remelting since recycled material 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.

Testing protocol: TBD

LABELS, INKS AND ADHESIVES

Some EPS recycling processes do not remove adhesive. The adhesive travels through the process with the PS and is blended in the final product. The most recyclable packages use the lowest quantity of adhesive that is compatible with PS. Lower adhesive usage reduces processing cost and potential contamination risk.

PREFERRED

Polystyrene labels

PS is the same material as the package so the label will behave like the package and be recycled along with it creating no added contamination or yield loss.

Direct printing

Most direct print inks withstand the standard EPS recycling process and remain on the package. Since no adhesive is used and the weight percent of label is extremely low compared to alternative labeling, they add little contamination to the final product.

High melting temperature plastic labels such as PET

These labels sink in the float sink tank if one is employed and remain solid in the PS extruder so they can be removed through filtering.

Also see "Requires Test Results" Section

DETRIMENTAL

Paper labels

Most paper labels remain on the package during the washing phase of the recycling process and enter the extruder with the PS. Paper degrades in the extruder emitting a burnt smell into the plastic that cannot be removed. Most of the paper can be filtered from melted PS but the smell and small individual fibers remain.

Polypropylene and polyethylene labels

Like most labels, PP and PE labels remain on the package during the washing phase of the recycling process and enter the extruder with the EPS. They will also float along with the EPS in a float/sink separation tank. Both PE and PP are liquid at the operating temperatures of the EPS extruder and cannot be removed by a filter. They contaminate the final EPS.

Also see "Requires Test Results" Section

RENDERS NON-RECYCLABLE

PVC

Float sink tanks are not perfect machines. Even though PVC sinks and the EPS floats small amounts of PVC travel with the EPS. The recycled EPS stream is very intolerable to even minute amounts of PVC since it degrades quickly at EPS processing temperatures, erodes machinery and creates a safety risk. Small pieces of PVC render large amounts of the finished product unusable.

REQUIRES TEST RESULTS

Metal foil labels

Metal detectors are employed in the recycling process to protect machinery. Even thin metal foil labels may be identified by detectors and cause the entire package to be rejected as waste, thereby creating yield loss. If not

detected, they pass through the process with the PS and cause contamination in the extrusion process. Since they remain solid in the extrusion process they can be filtered from the melted polymer which is advantageous over other materials that melt.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential for Plastic Articles Utilizing Metal; Metalized or Metallic Printed Components

Label adhesives

Most adhesives will remain on the package during the EPS washing process and enter the extruder with the PS. Adhesives should either remain solid so they can be melt filtered from the PS or be compatible with PS.

> **Testing Protocol**: TBD

ATTACHMENTS

PREFERRED

Clear PS attachments

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.

DETRIMENTAL

Paper attachments

The EPS reclamation process uses a wash to remove glue and other contaminants to the levels required to render the rEPS 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 final polymer. Paper fibers remaining in the rEPS carbonize when the material is reused causing quality degradation.

Welded attachments
A certain amount of a welded attachment cannot be separated from the main polymer in the recycling process. These attachments, whether made of floatable or sinking materials, cause contamination and yield loss issues when the EPS they are attached to causes the ground section containing both polymers to float.

RFID's (radio frequency identification devices) on packages, labels or closures
Unless they are compatible with EPS 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 yield, introduces potential contamination, and increases separation costs.

RENDERS NON-RECYCLABLE

PVC attachments

The use of PVC attachments of any kind on EPS packaging is undesirable and should be scrupulously avoided. Float sink tanks are not perfect machines. Even though PVC sinks and the EPS floats small amounts of PVC travel with the EPS. Very small amounts of PVC or PLA can severely contaminate and render large amounts of PS useless for most recycling applications.

REQUIRES TEST RESULTS

Non-PS attachments such as handles

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 sink in water such as filled PP/HDPE, or PET. If adhesives are used to affix attachments, their selection should consider the adhesive criteria within this document.

Testing Protocol: *TBD*

Metal, metalized and metal containing attachments

Sortation testing for metal components will result in either a Detrimental or a Renders Non-Recyclable ruling. Metal components cannot be Preferred at this time

Metal attachments to EPS are either detected by metal detectors at the beginning of the recycling process and cause the entire section to be rejected or they enter the process with the EPS where they wear and damage machinery before being separated in the float-sink tank. If they stay attached to the material, they can be floated into downstream equipment with the EPS and damage the machinery.

> **Testing Protocol:** SORT-S-03 Evaluation of Sorting Potential for Plastic Articles Utilizing Metal; Metalized or Metallic Printed Components

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.

Document Version History

Version	*Publication Date*	*Changes Made*
1	September 9, 2024	Combined all packaging material that does not meet access requirements into document for new location on new webiste