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 toughness, natural UV barrier properties and chemical resistance HDPE is one of the most widely used packaging resins. It is easily injection molded or blow molded into a bottle, pail, tub or closure. In its natural state, HDPE appears a milky white color. This is due to light reflection on the polymer structure rather than a colorant.

HDPE properties are commonly enhanced with colorants, additives and fillers, or it is placed alongside other polymers in a multi-layer package. Each modification and addition to the natural HDPE in a package must be considered for its effect on the recycling stream. Non-HDPE packaging features should either be economically removed from the HDPE in the typical recycling process or be compatible with HDPE in future uses. Of particular concern are mineral fillers or additives that cause the overall blend to sink in water. The density of HDPE is .94-.96 so it floats in water. Density is an important property as reclaimers typically rely on float-sink tanks to separate polymers and to remove contaminants.

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

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

The APR’s Recognition Program encourages consumer product, plastic package and bottle component manufacturers to utilize the APR Test Protocols to determine whether new modifications to a regularly recycled plastic package will negatively impact the recycling process prior to introducing the modification.
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### GENERAL LABELS, INK'S AND ADHESIVES

- **Inks**
  - X

- **Direct printing other than date coding**
  - X

- **In-mold labels of a compatible polymer**
  - X

- **Full bottle sleeve labels designed for sorting**
  - X

### ADHESIVES

- **Labels with thin Wash releasable, HDPE Compatible Adhesives**
  - PP, PE labels
    - X
  - Paper labels
    - X
  - Evaluation of Sorting Potential for Plastic Articles Utilizing Metalized or Metallic Printed Components
    - X

- **PVC or PL labels**
  - X

- **Polyethylene labels**
  - X

### LABELS WITH WEAK BLENDING ADHESIVES

- **PP, PE labels**
  - X

- **Paper labels**
  - X

- **Metal foil labels**
  - X

- **PVC labels**
  - X

- **PLA labels**
  - X

- **Polyethylene labels**
  - X

### ATTACHMENTS

- **PP, PE Tamper evident safety sleeves**
  - X

- **PETG Tamper evident safety sleeves**
  - X

- **PVC Tamper evident safety sleeves**
  - X

- **Non-PP attachments**
  - X

- **Metal and metal containing**
  - X

- **Plastic with a density > 1.0 except PVC**
  - X

- **Welded attachments**
  - X

- **PP**
  - X

- **SPID's**
  - X

- **PLA**
  - X

- **PVC**
  - X

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BASE POLYMER

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

BARRIER LAYERS, COATINGS & ADDITIVES

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

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

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

Test Protocol: HDPE Benchmark Test *This test is currently being developed.

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

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

Screening Test: HDPE/PP Degradable Additives Test
Workhorse additives historically used without issue are preferred.
Most HDPE in a package contains some form of additives. The “workhorse” additives commonly used have not been shown to cause significant issues with the recycling process or further uses of the recycled HDPE.

Commonly acceptable workhorse additives include:

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

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

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

**Test Protocol:** HDPE Benchmark Test *This test is currently being developed.*

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

**COLOR**

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

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

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

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

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

Benchmark Test: 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 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 three inches to a non-plastics stream, causing contamination in that stream, or directly to waste. These small packages are lost to the plastic recycling stream. It is possible that some small containers travel with larger ones when either the screens wrap with film HDPE PACKAGING
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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 2Dimensions Less than 2”

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

Closures & Dispensers

Polyethylene closures are preferred.
Since polyethylene is the same polymer as the package body, closures and dispensers made of it will be
captured and processed with HDPE. This increases the reclaimers yield and reduces possible waste.

Polypropylene closures are detrimental to recycling.
Since polypropylene floats in water like polyethylene it is not separated in the reclaimers float-sink tank. When
blended with HDPE it negatively affects the impact properties and can render the material brittle. Although very
small amounts of PP, such as that contributed by labels, are regularly accepted by HDPE reclaimers, closures and
dispensers comprise a larger weight percentage of the package and therefore a greater negative affect. The
APR recognizes that polypropylene is perhaps the most commonly used material for closures.

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

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

Pumps and spray dispensers containing metal parts require testing to determine the appropriate recyclability
category. Although metal is easily removed in the float-sink process, most reclaimers have metal detection
equipment designed to protect their cutting machinery. Therefore, the container never makes it to the float-
sink tank. Large metal items attached to HDPE packages may cause the package to be directed to the metal or
waste stream in the recycling process, causing yield loss. Metal springs, although not generally large enough to
trigger the metal detector, unravel during recycling and entwine themselves in screens designed to separate
water from the material thereby ruining the screen. This adds significant cost and downtime to the recycling
process. The APR encourages the use of polymer check valves and springs whenever technically possible. The
body of the spray dispenser or pump should also be the same polymer as the body of the bottle whenever

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technical possible to increase yield and decrease contamination of the recycled HDPE.

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

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

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

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

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

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

**LABELS, INKS AND ADHESIVES**

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

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

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

**Test Protocol:** HDPE Benchmark Test *This test is currently being developed.*

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

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

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

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

**LABEL-ADHESIVE COMBINATIONS**

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

**Polypropylene or polyethylene labels are preferred.**
HDPE labels are the same polymer as the final product and PP at the very small levels expected from label printing.

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residue has a very minimal negative impact. Therefore, these labels that remain with the HDPE throughout the recycling process, whether they detach or not, increase yield and have minimal negative quality impact for the reclaimer.

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

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

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

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

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

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

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

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

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

Test Protocol: HDPE Benchmark Test *This test is currently being developed.

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

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

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

Welded attachments require testing to determine the appropriate APR recyclability category.
A certain amount of a welded attachment cannot be separated from the HDPE in the recycling process. These

HDPE PACKAGING
attachments may cause recycled HDPE contamination and yield loss issues in both cases: when the ground section containing both polymers sinks and carries the HDPE with it, or when the ground section floats and carries an incompatible material with the HDPE into the extrusion process. Testing must show that the blend is of a density less than 1.0 so that it floats along with the HDPE in the float-sink tank, and that it is compatible with HDPE in the extrusion process.

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

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

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

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

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