PET Thermoform Packaging Design Resource Document

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Introduction

For the purpose of this document, PET thermoforms are defined as extrusion grade polyethylene terephthalate (PET) packaging labeled with the ASTM D7611 "#1, PET or PETE" resin identification code, not including bottles and jars, but including and not limited to clamshell containers, cups, lids, cake domes, covers, egg cartons, baskets, blister pack without paperboard backing, tubs, deli containers, trays, and folded PET sheet containers.

The most common way to recycle PET thermoforms today is to include them in bales of PET bottles produced at single stream materials recovery facilities, or MFRs. These bales are then sold to PET reclaimers who process the thermoforms together with the PET bottles—insofar as their process allows to meet their yield and customer specifications—to create recycled PET resins known as rPET. Some West Coast MRFs market PET thermoform-only bales, and although this is not yet common practice, PET thermoform markets and reclamation practices continue to evolve. At this time, APR's package design guidance for recycling PET thermoforms does not differ from that of PET containers as detailed in the APR Design® Guide for Plastics Recyclability. Thermoform package designers are encouraged to review APR Design® Guide for PET Rigid. The APR Design Guide provides what package designers need to know to make PET thermoforms that are compatible with the PET bottle stream.

However, because there is increasing interest in expanding collection and recycling opportunities for PET thermoforms, the APR has received requests to create a document that speaks specifically to the topic of designing thermoforms for recyclability along with the PET bottle stream. These include factors affecting PET thermoform collection, sortation and processing, as well as information pertaining to markets for recycled thermoforms and steps that can be taken to increase their recovery. This document was created in response to these requests by APR staff with support from several representatives from APR member companies that are thermoform and rPET industry experts.

In brief, top considerations for designing thermoforms to be compatible with the bottle stream are:

1. Employ clear PET (as defined by ASTM D7611) with an intrinsic viscosity (IV) between 0.72 and 0.90 dL/g.
2. Select labels and label constructions (label/ink/adhesive) that are categorized as Preferred for PET bottles and/or have received APR Recognition.
3. The size and dimensions of the package must support automated size and 2D/3D sorting. Common clam shells and tubs used for food products typically meet these requirements.

The document contains six sections:

Important notes: *This APR Resource Document is intended to provide educational material about recycling PET thermoforms and to present existing APR Design® Guidance for PET packaging within the context of PET thermoforms. This document is also intended to help package designers develop PET thermoform packaging that is technically compatible with the current PET bottle recycling stream,*

with detailing of specific thermoform factors that designers should consider to positively impact PET reclamation process and yields. Good design is an essential step in the acceptance of PET thermoforms in the marketplaces as a valued contributor to rPET supply. However, design alone is not sufficient to enable marketing claims of recyclability in communities in which this packaging format is not yet accepted for recycling. See APR definition of Recyclable for additional detail.

This Resource Document draws strictly from the APR Design Guide for Plastics Recyclability. This Resource Document does not create or offer new or different guidance. Should there be any perceived differences between this document and the APR Design Guide, the Design Guide takes precedence.

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.

PET Thermoform APR Design Guidance Summary Table

See also PET Rigid Design Guide

■ Preferred ■ Detrimental

Feature / Performance Element	*Preferred Material / APR Guidance*	*Potential Impacts & Design Considerations*	*Relevant Tests Performed on Thermoformed Package*
BASE MATERIAL / INTRINSIC VISCOSITY	**Preferred – PET and PET co-polymer resins with melting point between 225 - 255˚C.** **Intrinsic viscosity (IV) between 0.72 and 0.90 dL/g, with higher values being more desirable for PET recycling.** **The terephthalic acid or dimethyl terephthalate and monoethylene glycol reacted constitutes at least 90 percent of the mass of the monomer reacted to form the polymer.**	While not defined in APR design guidance, a thermoform resin IV at the upper end of the application IV spectrum helps with recycled material processing, improving yields and reducing costs. IV loss due to the incorporation of process regrind should also be considered.	*N/A*
PACKAGE SORTATION - ***Size*** - ***Shape*** - ***NIR*** - ***Color*** - ***Metals***	**Preferred – PET packages should be at least 2 inches (5 cm) in at least two dimensions.** There is currently no specific APR guidance re: label surface area coverage for PET thermoforms. Use of any metal films, foils, or metallic inks should not interfere with metal detectors.	While specific label surface areas guidance for PET thermoforms has not been determined, a label with a high surface coverage increases likelihood of incorrect sortation by resin (at MRF or reclaimer) and by color (at PET reclaimer). *PET **bottle** guidance for label coverage for NIR and clear (vs color) sortation:* - *Container <= 550 ml, no more than 55% label coverage* - *Container > 550 ml, no more than 75% label coverage.*	*Size:* SORT-S-02 *Shape:* SORT-S-05 *NIR:* SORT-S-01 *Clear / Color:* SORT-S-04 *Metals detection* SORT-S-03

Feature / Performance Element	*Preferred Material / APR Guidance*	*Potential Impacts & Design Considerations*	*Relevant Tests Performed on Thermoformed Package*
LABELS	**Preferred – PP or PE films with density of < 1 g/cm^3.** *Companies with APR Critical Guidance Recognition*	These materials readily separate from rPET flake for removal and recovery.	*Float/Sink Evaluation Screening:* PET-S-05
- ***Pressure Sensitive Labels***	**Preferred – Film labels.** See "Adhesive" below re: paper pressure sensitive labels.	Paper Labels: Paper must be filtered from rPET; fragments may sink w/rPET and affect its quality.	*Benchmark Screening:* PET-B-02 *Definitive:* PET-CG-02
- ***Metalized Labels (includes metal foils)***	**Preferred – coverage below requirements of RES-SORT-03b Metal Decoration Resource.**	**Potential issues for testing: Sortation** equipment detecting metal contamination will potentially sort packaging with metallized labels out of the PET stream; **Potential contamination** may result from metallized label if not ejected.	*Definitive:* SORT-S-03
ADHESIVES	**Preferred – Adhesives that wash off cleanly from PET and remain adhered to the label.**	These adhesives and labels wash off the PET before grinding or separate readily from rPET flake during processing.	*Benchmark Screening:* PET-B-02 *Definitive:* PET-CG-02
- ***Pressure Sensitive Label Adhesives***	**Preferred –Film labels with a wash-off adhesive.**	**NOTE:** Adhesives that are difficult to remove is the processing problem most often identified by PET reclaimers.	*Benchmark Screening:* PET-B-02 *Definitive:* PET-CG-02
- ***Standard Hot Melt Adhesive***	**Preferred – Hot melt adhesives should be tested to confirm they wash-off and do not re-deposit on PET.**	As mentioned above, adhesive selection is an important opportunity to improve rPET quality.	*Benchmark Screening:* PET-B-02 *Definitive:* PET-CG-02

Feature / Performance Element	*Preferred Material / APR Guidance*	*Potential Impacts & Design Considerations*	*Relevant Tests Performed on Thermoformed Package*
- ***All Other Adhesives***	Requires testing.	This includes heat seal coatings used for lidding films	*Benchmark Screening:* PET-B-02 *Definitive:* PET-CG-02
INKS	**Preferred – Ink retentive and de-inking technologies dependent on label substrate.**	**Ink retentive:** ink stays with label, which separates from rPET. **De-inking:** With a crystallizable PET label or direct print application, inks are washed away in caustic solution and micro-fragments are removed during filtration process.	*Benchmark Screening:* PET-B-02 *Definitive:* PET-CG-02
LIDDING - ***Film***	**Preferred – As with film labels, PP or PE films with density of < 1 g/cm^3 and that do not inhibit proper sortation.**	Crystallizable (cPET) lidding may require testing (to confirm it sinks in water). **Detrimental – PET/PETG laminate heat seal and Aluminum and paper composites.**	*Float/Sink Evaluation Screening:* PET-S-05 *Benchmark:* PET-B-02 *Definitive:* PET-CG-02 SORT-S-01
- ***Snap-on (rigid)***	Under Development		
Absorbent Pads	**Preferred – Use non-glued pads, or wash-off adhesive, or standard hot melt as described above.**	The APR has no specific guidance for pad structure; however, pad material can be tested to ensure floatation (no contamination to rPET) and minimize weight to reduce losses.	*Float/Sink Evaluation Screening:* PET-S-05 *Benchmark:* PET-B-02 *Definitive:* PET-CG-02

Feature / Performance Element	*Preferred Material / APR Guidance*	*Potential Impacts & Design Considerations*	*Relevant Tests Performed on Thermoformed Package*
Barrier Technology	Preferred - barrier materials must be tested.		*Definitive:* *PET-CG-01* *PET-P-12*
Additives	Additives require testing to be APR Preferred or have received Recognition.	**Detrimental – Optical Brighteners, Impact Modifiers and Nucleating Agents generally, as are others that have not yet been tested.**	*Definitive:* *PET-CG-01*
Color	**Preferred – Clear, light blue or light green*.**	**Detrimental – Other colors, due to low market value and yield loss.**	
Material Format	**Preferred – Mono-material PET**	Testing will be required on multi-material structure to show compatibility with PET.	*PET-CG-01*

* Light green is included to be consistent with the PET Design Guide, however, acceptance of light green thermoforms is not guaranteed per the PET Thermoform Bale Specifications.

Discussion of the Information in the Summary Table

Base Resin Selection / Intrinsic Viscosity and Melting Point

When thermoforms are recycled along with bottles, it is necessary that the resin used to make thermoforms is compatible with that used to make bottles and does not interfere with the bottle recycling process. Consideration must be given to resin appearance, composition, melting point and Intrinsic Viscosity.

Clear PET is valued for its high transparency and colorless appearance and has the most value for recycling. The APR does not have quantitative guidance on color values for PET base resin today. However, we do encourage those that specify PET resins to work with their suppliers to identify the best resins available that will result in low color in an initial application, and then have good color stability when the PET is recycled.

PET used to make bottles will crystallize and this crystallization is necessary for packages to be recycled successfully. Thermoforms made from co-polyester resins, such as PETG that are amorphous and do not crystallize, are not compatible with the bottle stream. Thermoforms made from polylactic acid (PLA), while also a polyester, are not compatible with mechanical PET recycling. When melt-blended with PET, small amounts of PLA create undesirable haze in the resulting recycled PET.

The APR Design Guide states that PET and PET co-polymer resins with a crystalline melting point between 225 °C and 255 °C are Preferred. Resins outside of this range, or that are non-crystallizable, are categorized as Detrimental. The Design Guide gives guidance on the desirable monomer compositions that provide this melting point range.

It is common for the Intrinsic Viscosity (IV) of thermoformed PET to be lower than that of PET bottle resin. The Design Guide recommends maintaining PET IV similar to that used for bottles when possible. This higher IV helps reduce the shattering or fracturing of thermoform material during the reclamation washing process, which results in a PET powder called fines that reduces material yields. Having a higher IV rPET flake material also means less residence time in the solid stating process required to get IV required for bottle rPET end market applications to the 0.80 to 0.84 dL/g range.

Sortation: Package Size, 2-Dimension / 3-Dimension, Color, Metal films

Accurate package sortation at MRFs is a precursor for all other evaluations (i.e., PET thermoforms must be accurately and positively sorted into a segregated PET bale). Sortation of thermoformed packaging will be impacted by individual package size, shape, color, and label coverage. Any use of metal foils or films can create interference with metal detection units.

From a minimum size perspective, a package that is larger than two inches (5 cm) in at least two dimensions is categorized as Preferred; smaller packages are more likely to fall through MRF size sorting screens and not be recovered for recycling. APR offers RES SORT-02 "Evaluation of Size Sorting Potential for Articles with at least 2 Dimensions Less than 2 Inches" to evaluate this. When evaluating package size, it is necessary to consider the size of the package after being exposed to compression, such as that experienced when recycled materials are compressed in a hauling truck. SORT-P-00 "A Practice for Compressing Plastic Articles for Laboratory Evaluation" details the compression steps.

Items that don't compress to a thin shape are categorized as Preferred, again due to their likelihood of traveling successfully through a MRF to a segregated commodity bale. RES-SORT-05 includes a table to determine the dimensional limits of a package given a known wall thickness and SORT-S-05 "Evaluation of the Two Dimensional/Three Dimensional (2d3d) Sorting Potential of a Whole Article" describes the definitive test.

As with PET bottles, black or dark color PET thermoforms are typically not detectable through NIR sortation at a MRF since the dark color absorbs (vs. reflects) the NIR signal. While there are now NIR-detectable black colorants in the marketplace, any colored PET that is sorted into a PET bale is categorized as Detrimental due to extremely limited markets for colored PET packaging, which negatively impacts yield and productivity. (See Color section below.)

Label coverage area should allow enough un-labeled package surface area to allow for correct NIR sortation as PET resin at a MRF, as well as for sortation (typically at a PET reclaimer) as a clear versus colored container. While the APR does not have label coverage design guidance specific to PET thermoforms, PET bottle guidance for Preferred label design for both correct resin and clear/color sortation suggests label coverage of no more than 55% of the bottle surface area for containers less than 550 ml, and no more than 75% of surface area for containers greater than 550 ml. Packaging with label coverage outside this range may be evaluated using SORT-S-01 and SORT-S-04.

Finally, it is common to use metal detectors when recycled plastics are being processed. The intent is to detect and eliminate large pieces of metal that can damage processing equipment. Although light-weight metal foils and vacuum deposited metal films will not damage process equipment, they may create a signal like that of larger metal in metal detectors, causing the package with a foil or metal film to be ejected and sent to a waste stream.

Labels, Adhesives & Inks

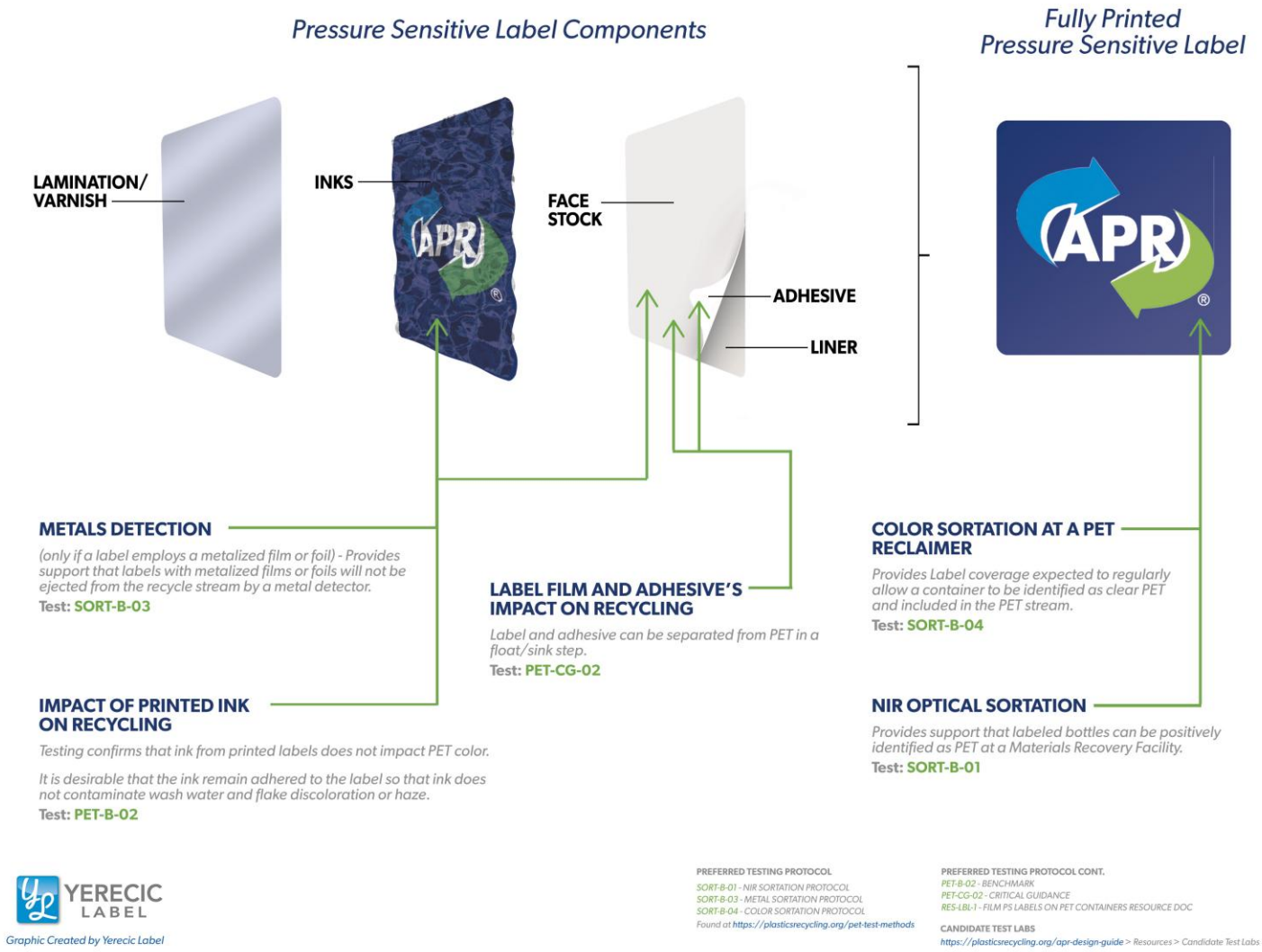
This category is an example of where priorities around package performance, regulatory compliance and recycling compatibility come together. The selection of recycling compatible labels, adhesives and inks is a key factor in furthering progress toward making PET thermoform recycling more commonplace and accessible to consumers. Certainly, product performance must be considered during material selection and tested to ensure supply chain viability. Products packaged in thermoforms (and their labels) often have unique challenges in terms of moisture, humidity, and condensation leading to complex structures as depicted in the image below, which shows a model label construction and the appropriate APR testing protocols. The transition to recycling compatible materials should ensure their successful application as well as meet any required regulatory compliance.

Using labels and adhesives designed for compatibility with PET recycling is one of the most important steps package designers can take to minimize the impact of PET thermoforms on the quality of recycled PET. Specifically:

- Adhesives are designed to wash cleanly from the PET surface and not contaminate the PET when recycled.
- Inks are selected that do not discolor PET during the recycling process.
- When film labels are used, they float in water and so can be easily separated from PET that sinks in water.

The APR Design Guide encourages the use of labels, inks and adhesives that are categorized as Preferred or APR Recognized. But if a label, such as a paper pressure sensitive label is employed that cannot be categorized as Preferred or has not received Recognition is employed, APR recommends the use of testing to employ label, ink and adhesive materials are selected to have the least recycling impact. The PET Thermoform APR Design Guidance Summary Table lists APR's test methods to evaluate the label/ink/adhesive characteristics.

If you are searching for an APR Recognized label material / adhesive / ink solution, please refer to the [APR Design Recognition Directory](#).



Label Adhesives

PET reclaimers processing thermoform material call out adhesives that are challenging to remove from recycled PET thermoforms during a standard PET wash process as potentially the most significant processing—and potential rPET quality—issue they experience.

Label adhesives require testing to demonstrate that they both wash off cleanly from the PET surface during recycling, and then do not redeposit on the flake during the wash process. Adhesives that wash off cleanly from PET and remain adhered to the label are APR Preferred. Label adhesive that is

not removed from PET, or which redeposits on the PET during the wash step, is a source of contamination and discoloration in recycled PET.

Paper labels are considered Detrimental to recycling by the APR. However, if paper labels are used, adhesives used for these labels, or to affix absorbent pads, should also be tested to demonstrate that they wash cleanly from the PET surface, and do not redeposit on PET during the wash process.

Heat Seals and Lidding Adhesives

Any heat seal coating, lacquer, or adhesive that is used to affix lidding film should wash cleanly off the PET and not redeposit on the flake after the wash process, similar to expectations for label adhesives.

Labels Substrate

Film labels are APR Preferred, specifically polymers with a density of less than one g/cm^3 that separate from the denser PET material in the reclamation process. Another APR Preferred label alternative, PET film labels that crystallize (cPET), may be recovered along with the PET stream, but must have ink designed to flake off during the PET flake wash process.

Paper labels are categorized as Detrimental to recycling. They often pulp up in the PET reclamation process and must be filtered out while non-pulping paper resists caustic washing and may stay with the PET. Paper labels also employ polymeric binders and coatings that can be sources of contamination when PET thermoforms are recycled. Traces of paper or polymer that stay with the rPET cause degradation of rPET quality. If paper labels are used, wash-off adhesives are especially desirable to reduce impacts.

Laminated label substrates require testing, as do metal foil, metalized and metallic printed labels that are above the coverage restrictions in RES-SORT-3b Metal Decoration Resource Document.

Inks

Ink retentive and de-inking technologies are Preferred options depending on the label substrate:

- Ink retentive technology has caustic resistance to bleed and avoids discoloring flake or wash water; the ink stays with the film label that separates from the PET and floats.
- For a crystallizable PET (cPET) label referenced in Label Substrate above, “de-inking” inks are washed away in caustic solution as micro-fragments, are removed during filtration process, and do not discolor flake or wash water. Both the cPET label and PET container can be reclaimed and recycled in this example.

- Due to the complexity of anticipating the impacts of the printed inks and label substrate combinations, APR suggests reaching out to APR member ink suppliers and label converters to better understand potential density and/or color bleed impacts as this topic is end-use specific with regard to label design.

Film and Snap-on Lidding

Film Lidding

As with film labels, lidding made from polymers with density of < 1 g/cm^3 is categorized as Preferred. Lidding made from polymers with density of >1 g/cm^3 is Detrimental since material sinks with PET causing contamination.

Thin PET film is potentially removed in the elutriation process or will float and be incompatible with the recoverable polyolefin float stream in the PET reclamation process. So, while cPET film lidding is a possible option (with guidance as detailed above for cPET labels and "de-inking" inks) additional testing is required to better understand if cPET lidding material will successfully sink with the recycled PET.

PET/PETG laminate heat sealable lidding cannot be removed in typical recycling processes and is categorized as Detrimental as the PETG has been shown to create clumping of PET flakes. Closures or seals that are compositions of aluminum and paper are Detrimental since they may contaminate wash water, or stick to PET or saleable closure material, reducing recycled material quality.

In terms of removable lidding (i.e., by a consumer prior to using or consuming product), it should be assumed that not all the lidding will be successfully removed and thus material selection should follow Preferred guidance or be tested to evaluate recycling performance.

Thermally laminated peel-off lidding should follow film guidance above so that it separates and floats from the recycled PET and leaves no residual adhesive on the rPET flake.

Snap-on (Rigid) Lidding

Due to potential sortation loss of small or thin items mentioned above, snap-on rigid lids should be put back on a package for better recycling capture rates ("caps on" as with PET bottles). To be Preferred, these lids should either be of the same resin (PET) if rigid lidding is clear, or from polyolefin material if color, so that the lidding material separates from the PET stream and is captured in the mixed color, polyolefin float stream. If the lidding is clear and PET, the use of a hinge attaching the

lidding to the base of the container will better enable capture of the lid with the base and increase yield.

Absorbent Pads (used to absorb moisture)

Ideally, specify pads that are not adhered to the PET thermoform with adhesive. If they are adhesively bonded to the package, use an adhesive developed to readily wash-off the PET surface. While the APR has not yet developed specific pad structure guidance, pads can be tested to ensure that they do not contaminate PET stream, *e.g., the pad material floats*. (There is industry work being done in this area with polyolefin pad structures.) The weight of the pad should be minimized to decrease yield loss at the reclaimer.

Oxygen Barrier Materials

There are some thermoform packaging applications where the shelf life of a food product packaged in the thermoform can be increased by using a thermoform with higher barrier to oxygen ingress from the atmosphere into the package. Oxygen barrier can be increased using multi-layer structures where a high gas barrier polymer or coating is used with PET. Another approach is to include an additive in the PET that reacts with oxygen and so reduces the amount of oxygen available to enter the package.

The Design Guide recommends that the impact of barrier materials on recycling be assessed by testing. It is, of course, desirable to use a barrier material that has received APR Recognition or has the least impact, if any, on the outcomes of PET recycling. Tests should assess:

- Any impact of the barrier material on NIR sortation.
- Impact of the barrier on color and haze in recycled PET.
- Impact of the barrier on IV and IV build rate of recycled PET.

Additives and Lubricants

Lubricants and de-nesting agents are widely used with thermoform packaging. There is no specific APR Design Guidance speaking to these materials today. Testing can be done to determine if there is any impact of lubricants on the color and haze of recycled PET.

Optical Brighteners, Impact Modifiers and Nucleating Agents are categorized as Detrimental. Each of these can potentially change the visual appearance of recycled PET and may influence its physical properties.

Color

Clear, unpigmented, light blue or light green[1] material is APR Preferred for all PET packaging. Recycled PET from color PET thermoforms, other than light blue, has extremely limited markets, as does green material. Because of this impact to reclaimer yield and productivity, the APR categorizes colored PET, other than the exceptions listed above, Detrimental to recycling at this time. This also includes natural crystallized PET thermoforms (CPET) as used in ovenable or microwavable packaging containers.

Black is typically not recyclable due to the NIR sorting issues mentioned in Sortation section above. NIR-detectable black solutions are available to aid with sorting, however this is not an APR Preferred solution for PET at this time due to the market limitations. (See CPET Trays and PET Thermoform Market Analysis sections below.)

PET Blister Packs - Laminated to Paper Board or Metal Foil

These packages are not likely to be recovered for recycling. Primary reasons include:

- Paper is undesirable in the PET recycle stream.
- Metal foils can cause packages to be ejected by metal detectors.
- Adhesives used in these materials may be difficult to separate from PET.
- Blister packs may be more two dimensional than three, thus sorting into the fiber vs. PET stream at a MRF.

Crystallized PET (CPET) Trays

CPET trays have historically been black and include a nucleating agent to promote crystallization of the tray so that it is resistant to heat in a kitchen oven. Standard black containers are not detected by NIR optical sorters commonly used at MRFs, and thus are likely to remain in MRF residue streams and not be sorted into PET bales. Aware of this challenge, CPET tray manufacturers are increasingly moving to natural (unpigmented) CPET. These trays are detectable as PET by MRFs' NIR sortation, although market and yield challenges remain for color PET. In summary:

- For black CPET containers, NIR detectable colors will be required to enable CPET trays to be sorted as PET by MRFs' NIR sorters;

[1] Light green is included to be consistent with the PET Design Guide, however, acceptance of light green thermoforms is not guaranteed per the PET Thermoform Bale Specifications.

- A CPET tray with no color added will be recognized as PET by MRFs' sortation, but will be sorted to the color PET stream by reclaimers because the CPET crystallization results in an opaque package that appears white (TiO_2 filled), although no TiO_2 is actually present.
- As mentioned in "Color" section above, black, white and other opaque color in any PET packaging is not APR Preferred at this time.

APR Recognition of Thermoform Packaging and Components

As the scope of the current PET Design Guide is limited to blow molded packaging, there is currently not an avenue to categorize a thermoform as being Preferred. Thermoforms are however eligible for APR's Critical Guidance Recognition through PET-CG-01 and PET-CG-02 and their individual components may be eligible for Preferred Design Recognition. This includes:

- PET Base Resins
- Complete Label Constructions for PET Packaging
- Label Substrates and Inks on PET Packaging
- Direct Print for PET Packaging
- Closures, Fitments, Liners, and Safety Seals for PET Containers

For more information on the APR Design® for Recyclability Recognition Program click here. To find components that have already achieved APR Recognition go to our APR Design® Recognition Directory.

When designing a PET thermoform it is recommended to utilize components that are either categorized as Preferred or carry an active APR Design for Recycling recognition to ensure the highest level of compatibility with the PET Blow Molded Bottle Stream. If/when additional guidance is developed which would categorize a Preferred Thermoform construct, recognition categories will be developed in parallel.

PET Thermoform Market Analysis

PET thermoforms are primarily recovered for recycling in two ways. There remain challenges with both approaches, as detailed below:

1) Sorted by MRFs into PET bottle bales at varying percentages. Mid-sized to large MRFs typically use optical sortation to positively sort all PET containers (by resin), baling PET bottles and PET non-bottle (thermoform) packaging together. Some small MRFs sort by hand so have the option to add non-bottle PET to their bales, *or not,* depending on their market specifications.

Much of this thermoform material gets processed with bottles, but with PET reclaimers' systems set up to run bottle material, tolerance for thermoform material is inconsistent across the North American PET reclamation industry, ranging from a few percent to considerably more. The challenges with mixing these two PET package formats are primarily around increased yield loss, both through front end sortation and process loss due to thermoforms' higher propensity for shattering and fines when run in lines set for bottles. Look-alike clear thermoforms (e.g., PVC, PS, PLA) cause contamination to the PET stream, thus optical PET sortation at MRFs (versus hand sortation) is preferred by reclaimers that process thermoform material. In addition, thermoforms can fold around and "grip" other materials in a way that bottles do not, inadvertently bringing in non-PET plastics, metals, fiber and other contaminants.

2) Sorted into dedicated PET thermoform-only bales. MRFs that market a dedicated PET thermoform-only bale typically optically sort all PET packaging, then use robots or hand sortation to separate PET thermoforms from PET bottles. The latest sortation technology uses Artificial Intelligence (AI), in conjunction with robots, to identify and sort PET thermoforms from PET bottles. (It should be noted that optically sorted PET thermoforms are preferred by reclaimer markets, as detailed in Model Bale Specifications for PET, to minimize disruptive look-alike material, e.g., PVC, PS.)

   There are some MRFs that segregate PET thermoforms for processing, primarily in California and Canada, and some subscription-based or retail collection systems that include PET thermoforms. There are a few North American PET reclaimers that adjust their processing settings to more efficiently run dedicated PET thermoform material, or that have built dedicated PET thermoform reclamation systems, but it's not in widespread practice at this time. Increased market demand by package converters and brand companies for recycled PET thermoform-specific content is a critical driver of the PET thermoform sortation and processing value chain. Current challenges include inconsistent demand for rPET from thermoforms, driving limited reclaimer processing of thermoform material and, in turn, tepid incentives to MRF suppliers of thermoform-only bales in terms of economics and buyer breadth.

It's likely that both pathways will continue to be explored for their viability in the near term as the economics, market incentives and policy drivers such as EPR evolve. (Current APR model bale specifications for PET bales include PET Bottles, PET bottles with Thermoforms, and PET Thermoforms.)

Over the last five years, U.S./ Canada reclamation of PET thermoforms has averaged 100 million pounds per year across the combined recovery methods described above, Estimates of total PET

thermoform material generated in the U.S. / Canada hovered at 1.6 billion pounds in 2018. Factoring in growth and imported, pre-packaged goods (e.g., berries), there is no question that this is a significant commodity stream.

The percentage of U.S. residents able to recycle PET thermoforms through their local collection programs is estimated at less than 60% in the most recent published recycling availability report (2024); this does not meet the threshold for making unqualified recycling claims as defined in current Federal Trade Commission "Green Guides."

Factors Influencing Progress

The three factors below are interlinked and essential to take PET thermoform collection and reprocessing to the next level, addressing the critical intersection of commodity quality and yield, collection, and end market demand.

Design for recycling. Designing thermoforms to be more compatible with the PET recycling stream is an important step in increasing PET reclaimers' ability to process these materials successfully, reducing potential yield loss and extra processing resources. For PET reclaimers that process PET thermoform material, label adhesives are an identified challenge.

Markets. Brands specifying recycled PET derived specifically from thermoforms in their contracts with package converters is needed to pull recycled PET thermoform material through the system. This is an essential driver in today's marketplace and is necessary to help offset PET reclaimers' familiarity with, and preference for, recycled PET bottle feedstock.

Policy. Policy has the potential to nudge PET thermoform recovery and circularity in a positive direction. Examples include Extended Producer Responsibility (EPR) laws and recycled content requirements. PET thermoforms are a packaging category that will be considered under all five EPR laws passed to date (OR, CA, CO, MN, ME), although how they are considered, collection methods and requirements will vary. As mentioned above, PET reclaimers' interest in buying and processing this commodity material is directly dependent on the two factors above: improved material quality and consistent packaging converter / brand buyers for recycled PET thermoform resin.

Recycled content requirements, either as part of EPR incentives or in stand-alone laws, help build and stabilize recycled resin markets and level the competitive playing field for brands and package converters. Providing incentivizes for the use of domestic or North American recycled resin is key to

establishing market drivers and the collection-processing-remanufacture circularity that is the primary objective of recycled content requirements.

EPR laws commonly require graduated producer fees to promote good packaging design and discourage bad. California's EPR law requires that the producer fees developed account for any difficulty of recycling covered (plastic) material that is caused by detrimental elements as defined by the APR Design® Guide. See more about how policy fits and why it's important in the FAQ section below.

Frequently Asked Questions (FAQs)

Why is size sortation considered for recyclability

The sortation of thermoformed packaging will be impacted by its size, compression, color, and label coverage. A package that is larger than two inches in at least two dimensions is categorized as Preferred; smaller packages are more likely to fall through MRF screens and not be recovered for recycling.

If I use a black or dark colorant that is designed to be detectable by NIR, won't that be Preferred for PET thermoforms?

There are now NIR-detectable black colorants in the marketplace, however, color PET thermoform material that is sorted into a PET bale is categorized as Detrimental due to extremely limited markets, which negatively impacts yield and productivity.

What is the maximum label size I can use if I want my thermoform to be recyclable?

While the APR does not have label coverage design guidance specific to PET thermoforms, PET bottle guidance for Preferred label design for both correct resin and clear/color sortation suggests label coverage of no more than 55% of the bottle surface area for containers less than 550 ml, and no more than 75% of surface area for containers greater than 550 ml. Labeled material may be tested using Sorting Potential Test for NIR and Clear sortation (SORT-S-01, SORT-S-04).

Why are paper labels a problem for recycling?

Paper labels are categorized as Detrimental to recycling. They often pulp up in the PET reclamation process and must be filtered out while non-pulping paper resists caustic washing and may stay with the PET. In both cases, traces of paper that stay with the rPET cause degradation of rPET quality.

I've heard that adhesives can be a challenge for PET thermoform recycling. Why is this and are these challenges specific to certain label types?

Adhesives that wash off cleanly from PET and remain adhered to the label are APR Preferred. Label adhesive that is not removed from PET, or which redeposits on the PET during the wash step, is a source of contamination and discoloration in recycled PET.

What are the best inks to use and how does the choice of inks relate to the label substrate?

Ink retentive and de-inking technologies are Preferred options:

- Ink retentive technology (used with pressure sensitive labels) has caustic resistance to resist bleed and avoids discoloring flake or wash water; the ink stays with the film label that separates from the PET and floats. This typically occurs with pressure sensitive label types.
- For a crystallizable PET (cPET) shrink label referenced in Label Substrate above, "de-inking" inks are washed away in caustic solution as micro-fragments are removed during filtration process and do not discolor flake or wash water. Both the cPET label and PET container can be reclaimed and recycled in this example.

What about films for lidding? Are they like labels?

As with film labels, lidding made from polymers with density of < 1 g/cm^3 is Preferred. Lidding made from polymers with density of >1 g/cm^3 is Detrimental since material sinks with PET causing contamination. Labels should not inhibit accurate identification as PET resin, i.e., by MRF NIR sortation.

Can crystallized "dual ovenable" PET (CPET) trays be recycled?

These are trays that are most often used for frozen foods that can be reheated in either a microwave or convection oven. They will contain a nucleating agent to promote crystallization and heat resistance of the tray.

As mentioned earlier, if these trays are a standard black color, they are not correctly identified as PET by MRFs' NIR sortation. With an NIR detectable black color, they will sort as PET, and subsequently be sorted into the mixed color stream by PET reclaimers. Even if no color is used (e.g., a natural CPET tray), these trays will appear white in color and will be sorted into a mixed color stream.

There are very limited markets for color PET containers of any type, and they negatively affect reclaimer yields, so they are not categorized by APR as Preferred.

Can thermoforms or blister packs bonded to either cardboard or aluminum foil be recycled?

Aluminum foil bonded to PET is likely to cause a rejection at a metal detector. Manual sortation would also be used to remove such packages from the recycling stream.

PET bonded to a cardboard packaging component is also expected to be removed by those doing manual sorting and sent to a waste stream. The paper and adhesives used in this case are not desirable in the recycling stream.

As a brand owner, how can I help increase PET thermoform recycling?

Design for recycling. Designing thermoforms to be more compatible with the PET recycling stream is an important step in increasing PET reclaimers' ability to process these materials successfully, reducing potential yield loss and extra processing resources. If you are reading this resource document, you're on the right track.

Markets. Brands specifying North American recycled PET thermoform material content in their contracts with package converters is helping pull recycled PET thermoform material through the system. As mentioned above and below, this is a critical driver in today's marketplace and is the necessary "demand" side to pair with the "supply" increase anticipated as EPR laws take effect.

Where is public policy with respect to PET thermoforms? (Why should I care about design for recycling?)

Please see" Factors Influencing Progress" above.

Under the five EPR laws passed to date, recovered PET thermoform volumes are expected to increase. It will be critical to balance this new supply with strong end markets for recycled PET thermoforms, i.e., brands and packaging converters that specify recycled PET thermoform material from their North American suppliers.

Designing a package for recycling compatibility, as detailed in this document, improves material yield and quality, offering reclaimers a better commodity stream and package and product manufacturers, a better recycled PET thermoform resin. EPR law typically incentivizes design for recycling and recycled

content usage in its producer fee structure, with California's law requiring this in its fee development and citing the APR Design Guide.

In terms of mandatory recycled content laws passed to date that affect PET thermoforms, New Jersey's requirement for content in rigid packaging took effect in 2024 but exempts food packaging until 2027. (Milk products, medical food, special dietary food and infant formula and exempted.) California's Rigid Plastic Packaging Container law remains in effect, but exempts categories including food, cosmetics, drugs, medical, and infant formula.

DOCUMENT VERSION HISTORY

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