The Association of Postconsumer Plastic Recyclers

APR Shrink Label Working Group

Final Report

September 2014

Executive Summary

Full shrink sleeve labels have gained popularity in recent years because of their attractive shelf presence. While very appealing to the consumer, shrink sleeve labeled PET bottles are not friendly to PET recyclers. Shrink sleeve labels can interfere with the accuracy of automated sortation equipment. Because many shrink sleeve labels today are PETG-based or PVC-based film with density higher than water, they cannot be separated from PET flakes during the sink-float separation step of the recycling process, and thus contaminate the recycled PET stream and deteriorate the quality of recycled PET (rPET) products. Poor ink adhesion on shrink sleeve labels contaminates wash/rinse water and can stain the color of rPET.

An APR Shrink Label Working Group was formed in June 2013 to address the issues created by shrink sleeve labels; that is, identify steps that allow brand owners to take advantage of the benefits of sleeve labels, but without a negative impact on the cost and quality of rPET. The Working Group had a broad composition across all segments of recycling industry and label supply chain, including PET reclaimers, brand owners, material suppliers, equipment vendors, and testing labs. It was organized into six sub-teams to address (1) industry impacts of shrink sleeves to recyclers; (2) bottle sortation technologies; (3) label removal methods and equipment; (4) commercial floatable labels; (5) ink bleeding mitigation; and (6) updating test methods.

This working group has been effective in developing objective information and recommendations that the packaging industry can use to minimize the impact of sleeve labels on recycling of PET bottles.

Most of the cost impact of full sleeve labels falls on those PET reclaimers who buy curbside recycle bales which contain the highest percentage of bottles with shrink sleeve labels. This cost impact is estimated on the order of 2 to 4 cents per pound, or $44 to $88 per metric ton, of all finished rPET flakes, not just the flake from the bottles with the full sleeve labels. Bales of deposit bottles are not expected to have many shrink sleeve labeled bottles because locations where there are bottle bills cover primarily CSD bottles and water bottles which have not typically displayed shrink sleeve labels.

To reduce this cost impact, for those brands choosing to use sleeve labels, the Working Group recommends:

- Employ sleeve labels that will float in water and separate from PET flakes in a sink/float material separation step.
- Employ printed labels where the label inks do not stain PET flakes in the wash/rinse step.

- APR's Critical Guidance Document for Shrink Sleeve Labels on PET Bottles is a comprehensive laboratory test program to assess the impact of shrink sleeve labels on recycling of PET bottles.
- Where possible, employ a sleeve label that leaves at least 20% of the PET bottle surface area exposed – either the un-labeled area itself, or the un-printed area of the label allow at least 20% of the bottle surface to be seen. This label design will allow for most accurate auto-sortation by the broadest range of installed color sorters.

There are now commercially available "TD" and "MD" shrink label technologies that meet APR Critical Guidance Criteria. The list of recognized companies and labels is given on the APR web site www.plasticsrecycling.org

Sortation studies presented in this report have shown that allowing about 20% exposure of the PET bottle helps insure that the broadest range of installed color auto-sorters can accurately identify a clear PET bottle beneath the label. Many, but not all, NIR unit configurations were shown to be capable of identifying a PET bottle beneath a full shrink olefin label. Although not tested, we expect the 20% PET surface exposure to help improve NIR sorting accuracy as well.

A move to low density floating labels, less surface coverage, and employing the thinnest possible label stock all combine to minimize the weight of label stock consumed in the supply chain, and to minimize the amount of label stock that has to be disposed of as part of the PET reclaiming process. For example, if a 4 gram shrink sleeve label is used on a 31 gram bottle with a 3 gram closure, the label represents over 10% of the total package weight.

Until new recycle-friendly sleeve label materials and designs are in wider use, some PET reclaimers may choose to invest in new process equipment to help manage bottles with sleeve labels. One of the Working Group teams surveyed equipment suppliers for de-labeling machinery and other equipment options that can help separate label residue from PET flake.

Considerable effort was also given to up-dating the APR test methods that are available to innovators for evaluating the impact of labels on the recycling process. These tests allow brand owners a quantitative means to compare label product offerings. These up-dated tests provide consistency between tests offered for both sleeve and pressure sensitive labels.

There are factors that make the adoption of new sleeve label technologies slow. Even though there has been one floating-label introduction in North America, we cannot expect a wide spread change in label technologies for at least two to three years' time. Chief among those is the cost parity to existing labels. Many brand owners indicate that they are unable to pay a premium for recycling-friendly shrink labels over the existing labels. In addition, supply contracts usually run at least one year, or longer, and brand owners need to honor the existing contracts.

New "MD" label technology is receiving considerable industry attention because of its promise to provide faster application speeds as well as be functional with olefin based labels. But this label approach requires investment in new label application equipment and will be adopted slowly.

There are, however, factors that influence brand owners to adopt the new recycling-friendly label technologies. Many brand owners are users of food-grade recycled PET resin and specify rPET content in their bottles. The cost, quality, and supply of food-grade recycled PET resin matter to them and is critical to any sustainability program. There may also be pressure from industry groups and NGOs; concern for bad press; and new package recycling guidelines promoted by retailers that encourage change.

The APR's role can now transition from alerting the industry to the shrink sleeve label problem, to a role where we encourage change and support brand owners in pulling though new label technologies. APR has already created an APR Label Communications Working Group to communicate label information impacting recycling and sustainability to the supply chain. This Communications Working Group will also measure progress towards adoption of new label technology.

The APR will also continue to encourage label innovations and be available to support innovators develop and demonstrate new technologies that benefit the PET supply chain and postconsumer recycling. There are development efforts in the industry involving label perforations, means for labels to be removed in whole bottle wash steps, new ink technology, advances in auto-sortation equipment, and advances in recycle process equipment. It is in everyone's interest to see these fully explored.

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Recommendations and Next Steps

There is no single step that will eliminate the impact that shrink sleeve labels have on PET recycling. The recycling industry, label supply chain, and brand owners can cooperate and take combinations of approaches presented in the report.

- For brand owners, we recommend to select floatable, recycling-friendly shrink labels that employ non-bleeding inks; APR's Critical Guidance Document for Shrink Sleeve Labels on PET Bottles can be used to confirm the floating and ink performance of label candidates. We also recommend the use of shorter labels or decorated labels with at least 20% clear window of graphics to allow auto-sortation on the widest range of installed equipment. Label designs which facilitate label removal are encouraged: perforations on labels are one approach. A method for "de-seaming" labels in a whole bottle wash is in development and may be commercially available. The use of thinner gauge labels to reduce the impact of label weight on bale yield loss and waste disposal is also encouraged.

- For shrink film manufacturers and label converters, we recommend to offer floatable shrink labels meeting APR Critical Guidance Criteria and with superior label properties and distribution performance. Feature label designs and graphics that enable effective auto-sortation by color and NIR units. Competitive pricing/value against the current shrink labels will be required to win acceptance. For those who continue to offer PETG-based shrink labels, participate in commercial development of the whole bottle wash de-seaming technology, and offer thinner gauge PETG shrink labels.

- For ink suppliers and label converters, we recommend to offer advanced printing technologies that prevent ink bleeding via, for example, UV-cured or E-beam-cured varnish or solvent-based inks. APR's Critical Guidance Document or Bleeding Ink Test can be used to assess ink bleed.

- For reclaimers, investment in new process and auto-sorting capability may be necessary to manage the impact of sleeve labels until the time when new label technologies are more widely adopted. Additional manual sorting may also be required.

APR has already created a Label Communication Working Group to pick up where this Technical Working Group finishes by communicating and promoting the solutions to the brand owners and shrink label industry. The team will call on brand owners to communicate and ask for feedback. It will also prepare communication points of the findings and solutions to present to other trade associations, to have interviews with trade journals, and put out press releases to promote recycle-friendly shrink label solutions.

Conclusions of Working Group Study

The Working Group covered a lot of ground. Below, in no particular order, is a listing of major findings of the Working Group:

- With the recent efforts by recycling industry and label supply chain groups, such as APR, NAPCOR and the Sleeve Label Consortium, many brand owners are now aware of shrink sleeve label problems with PET recycling. Some brand owners have decided to set a moratorium to temporarily delay the introduction of new shrink packages using PETG shrink sleeve label until recycle-friendly solutions have developed.

- However, label industry indicates that shrink sleeve label market continues to grow, albeit at a slower rate than previously predicted. Recyclers have reported that shrink sleeve labels continue to cause problems in yield loss and quality deterioration of recycled PET production, which hamper their capability to supply clean recycled PET.

- It is reported that shrink labeled bottles are mostly in curbside recycled PET bottle bales, and present a significant problem for recyclers who purchase curbside recycled bales. Depending on the bottle deposit laws in various bottle-bill states, shrink sleeve labels usually are less a problem in deposit bottle bales. Furthermore, recyclers using wet front-end recycling process with whole bottle hot prewash step also tend to have more problems with shrink sleeve labels since shrink sleeve labels would shrink further upon hot wash and tightly hold onto the bottle instead of releasing. By contrast, recyclers using dry front-end recycling process with granulation step to make PET flakes tend to have fewer problems with shrink sleeve labels relative to holding onto the PET. Non-floating sleeve labels cause disruption to both processes.

- It is estimated by the industry impact sub-team that the cost impact of shrink sleeve labels is about 2 to 4 cents per pound of clean PET flakes, or $44 to $88 per metric ton loss of income. This is for all clean flake produced, not just that from bottles with the sleeve labels. Thus, shrink sleeve labels hurt the profitability and financial health of the recycling industry. Some recyclers hurt more than others, particularly for those recyclers already operating at very thin margins. Yield loss due to pulling aside shrink labeled bottles and extra expenses for mechanical label removal equipment could lead to financial difficulties of those recyclers.

- In recent years, bottle sortation equipment vendors have improved the capability of their polymer sort equipment and software to sort shrink labeled bottles via NIR sorters either by transmissive or reflective mode. The newer NIR sorter can penetrate the shrink label and identify the bottle resin underneath the label. However, the older sorter equipment may require software upgrade or hardware upgrade in order to improve its capability. Furthermore, effective color sort on the bottle would require either a shorter label or a label with at least 20%

clear window to expose the bottle underneath in order to facilitate the identification of clear or green or opaque bottle.

- Mechanical de-labeling machines are in general about 70 to 90% effective in removing shrink sleeve labels depending on operating conditions. However, the machines also tend to cause the loss or damage to bottle necks, which account for about 25% of the bottle weight. Costs of equipment, installation, and maintenance of de-labeling machine are quite substantial. Because of the friction mechanism of the de-labeling machine, the parts tend to wear out fast, and the machine needs to be taken offline frequently for maintenance. However, until floatable labels or other mitigating measures are widely used, mechanical de-labeling machine appears to be an expedient stopgap, but high-cost, partial solution to managing shrink label problem at recycle plant.

- Perforations on shrink labels seem to also help the removal of the label on the de-labeling machine. However, perforation patterns need to be evaluated on distribution trial of the finished products since perforations tend to weaken the shrink labels and may lead to damaged/frayed labels before the products reach consumer's hand.

- There is an alternative technology of de-seaming of shrink labels currently under development, which can be considered as chemical de-labeling. The adhesives or glues at the seam of shrink sleeves can be dissolved under whole-bottle wash condition, and label can be washed away in the same way as the current roll-fed OPP labels. The de-seaming technology is currently focused on PETG shrink labels, but presumably can also be applied to floatable, polyolefin shrink labels in the future as well.

- Besides mechanical de-labeling, perforations, and de-seaming technology for wet front-end recyclers, there are also other label separation technologies for dry front-end recyclers, such as electrostatic separation, elutriation, hydrocyclone, and colored flakes sorting, which can also help removing shrink labels from PET flakes effectively.

- In past couple years, many shrink film manufacturers have been active in developing floatable films for shrink label applications. The density of those floatable films is less than one, thus they can float in the sink/float water tank to separate from PET flakes during recycling process. Their compositions are usually either polyolefins or composites of polyolefin core with PET, PETG, or OPS skin layers.

- As to shrinkage orientation, there are transverse direction (TD) shrink labels and machine direction (MD) shrink labels. TD shrink labels are usually pre-seamed into sleeve tubes which are slipped onto bottles on the TD label application machine on bottling line. By contrast, MD shrink labels are usually made by seaming the roll-fed films into sleeves on mandrels of the MD label application machine, and bottles are dropped into sleeves. Shrink sleeves on the bottles are then shrunk in a heating tunnel or steam tunnel to conform to the shape of the bottles.

- These new floatable, recycling-friendly shrink labels need to be confirmed for their recyclability according to APR Critical Guidance Document for Shrink Sleeve Labels to make sure that (1) they do separate from PET flakes in sink/float tank by the virtue of density less than one; (2) the injection-molded plaques made from washed PET flakes meet color and haze requirements; (3) the washed PET flakes pass the clumping test, and do not cause agglomeration due to low-melts contamination.

- Graphics on shrink sleeve labels are usually either surface-printed or reverse-printed. Inks on shrink labels need to stay on the floatable labels with minimum ink bleeding during caustic wash step of recycling process. Ink suppliers have done extensive studies to develop inks and printing technologies to meet APR ink bleeding requirements. UV-cured or E-beam-cured varnishes appear to offer the best results. Some solvent-based inks also seem to offer good results. But water-based inks usually do not do well. When evaluating printed labels, generic graphics containing CMYK+W inks would be most appropriate.

- For the last two years, Label Sub-Committee of APR Technical Committee has worked to update and improve the test methods for shrink labels, including APR ink bleed screening test protocol, ink bleed benchmark test protocol, and shrink label recyclability critical guidance document test protocol. Label suppliers have been employing these tests, and leading brand owners have also been asking that these tests be used. And APR guidance recognition program is also being sought after by film manufacturers, label converters, and brand owners.

- As mentioned earlier, there have been a lot of new label technologies developed or under development, but brand owners seem to be slow to adopt them. From brand owners' perspectives, there are some hurdles for them to overcome before adopting recycling-friendly label technologies. First of all, the cost parity to existing label – Brand owners are reluctant to pay premiums for recycling-friendly shrink labels over the current non-recycling-friendly shrink labels. Second, an extensive distribution and label performance tests of new labels are required. Third, simulated recycled bales of labeled bottles need to be trialed at recycle plant to ensure they can indeed be successfully recycled. Fourth, there are operation risks at the bottling plant running the new label, and market risks at the marketplace, such as consumer's acceptance of new label technologies. Fifth, capitals may be required for new label application machine if there is a need to switch between TD and MD shrink labels. And finally, they are obligated to honor the existing contract, which may take some time to run out.

- Conversely, there are several factors influencing brand owners to adopt recycling-friendly label technologies. First and foremost, pressure from industry groups and NGO's, bad press, and non-compliance notices such as APR NAG (Not According to APR Guidance) letters. Major brand owners always want to avoid the spot light of bad press and external conflicts attracting attention. Second, many brand owners are also users of food-grade recycled PET for their rPET bottles. Higher cost, poor quality, and inadequate supply of food-grade recycled PET resin are undesirable to them. Third, the recent announcement of Wal-Mart's Design-for-Recycling (DfR) guidelines gives them incentives to stay on the good side of packaging recyclability. Fourth, many brand owners are genuinely supporting the recycling industry and want to see a healthy recycle industry for the sake of environmental sustainability. Finally, many companies have corporate sustainability goals or scorecard which they need to maintain good corporate image and to respond to Wall Street and shareholder expectations.

Background and Introduction

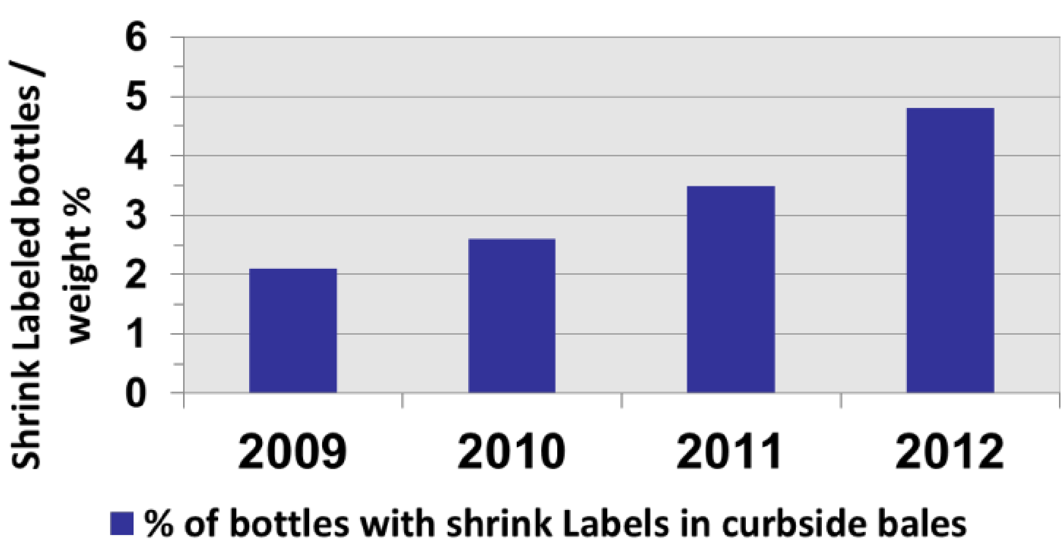
Shrink sleeve labels has been gaining popularity in marketplace in recent years. They offer more bill-board space for marketing messages with shining and attractive graphics which appeal to consumers. Documented increase of sales volume demonstrates that consumers indeed respond very positively to shrink sleeve labels.

However, most of shrink sleeve labels in marketplace are PETG-based films with density higher than one. They contaminate recycled PET flakes because they do not separate from PET bottle flakes during the sink/float step of PET recycling process. By contrast, OPP roll-fed labels with density less than one easily separate from recycled PET flakes because they float to the top of sink/float water tank.

PETG is a low-melting material, and tends to cause clumping or agglomeration of PET flakes when drying in a vacuum oven or commercial dryer for PET processing. In addition, inks on PETG label decorations are carried over to the recycled PET flakes when the PETG and PET particles are not separated and reduce the quality of recycled PET material with darker color and higher haze.

Besides PETG, other shrink sleeve label materials being commercially used include PVC, OPS, and PLA. All of them have physical properties similar to those of PETG, including clumping during drying, and tend to contaminate recycled PET flakes as well. Among those, PVC shrink label in particular is the most detrimental to PET recycling and should be absolutely avoided because even a tiny amount of PVC would generate hydrogen chloride gas during high-temperature extrusion and cause black specks and yellowing in recycled PET products.

PET recyclers have reported gradual increase of shrink labeled PET bottles in recycled PET bottle bales over the past several years. Many recyclers are not able to process shrink labeled bottles, and have to pull them out and kept them temporarily in the storage yard. Eventually, these contaminated bottle bales are either sold for substantial loss or disposed off to landfill.



Shrink sleeve labeled bottles pulled from recycled bottle bales

Due to the presence of increasing amount of shrink sleeve labels in recycled PET bottle bales, many recyclers suffer significant yield loss, poor product quality, and unhealthy operating margins. They are not able to produce the same amount of good quality recycled PET materials from bottle bales as in the recent past. This has become an increasing industry-wide problem for PET recyclers.

Recognizing the bad situation, in October of 2011, NAPCOR (National Association of PET Container Resources) sent a complaint letter to the CEO's of five leading U.S. beverage companies on the recycling problem caused by shrink sleeve labels in their packages. And in March of 2012, NAPCOR again issued a press release to call the attention of packaging industry to the shrink sleeve label issue.

Meanwhile, APR Technical Committee has been working on recycling evaluation of shrink labeled bottles since early 2011, and issued the shrink label recyclability test protocol in July of 2012, which NAPRCOR endorses. Many APR members have also working either independently or cooperatively on the solutions to the shrink label recyclability problems in the last three years.

Early in 2011, David Cornell, APR Technical Director at the time, proposed four principles for recyclable shrink labels as guidelines for recycling-friendly labels –

1. Label does not interfere with sortation.
2. Label best if removed in whole bottle wash.
3. Label floats.
4. Inks do not discolor flakes.

In June of 2013, APR decided to form an ad hoc industry-wide Shrink Label Working Group with the mandate to specifically address the shrink label issue. It has a broad composition consisting of 19 companies including reclaimers, brand owners, material suppliers, equipment suppliers, testing labs, and industry experts. It is organized into six sub-teams to –

1. Assess industry impacts
2. Evaluate sortation technologies
3. Examine label removal methods
4. Identify floatable labels
5. Mitigate ink bleeding in wash
6. Update/develop test methods

Company	Industry segment
PepsiCo	Brand owner
The Coca-Cola Company	Brand owner
NRT	Equipment
Common Sense Solutions	Consultant
Exxon Mobil / Jindal Films	Film supply
Klockner	Film supply/reclaimer
Avery Dennison	Film supply
Polysack	Film supply
Printpack	Label converter
ShrinkPak Solutions	Shrink sleeve consultant
Eastman	Material supply
MRC Polymers	Reclaimer
Clean Tech	Reclaimer
Clear Path Recycling	Reclaimer
Allan Company	Material recovery
PFE	Testing lab
PTI	Testing lab
Flint Group	Ink supply
Sun Chemical	Ink supply

	Sub-Team	Members
1	Industry Impact	Curt Cozart, Jim Kulp, Dean Eberhardt, Lou Tacito, Jay Chilton, Chip Lavigne
2	Bottle Sorting	Matthias Erdmannsdoerfer, Kristi Hansen, Weilong Chiang, Dave Hill, Robby Parrish
3	Label Removal	Michel Gosselin, Curt Cozart, Dean Eberhardt, Frank Schloss, Carl Williams, Jeff Meyers
4	Floatable Label	Kevin Frydryk, James Taylor, Bob Schantz, Roni Ben Shoshan, Weilong Chiang, Carl Williams, Mark Danner
5	Ink Bleeding	Roni Ben Shoshan, Kristi Hansen, James Taylor, Harold Osorio, Weilong Chiang, Jeff Sherwood
6	Test Methods	Frank Schloss, Lou Tacito, Helen Rallis, Kevin Frydryk, Kristi Hansen, Adrivit Roy, Mark Danner

The Working Group met bi-weekly from August 2013 to October 2013 via conference calls, and each sub-team also met bi-weekly before the whole Working Group meeting. It presented the interim report at APR October Meeting in Greenville, NC on 10/10/2013 on preliminary findings and recommendations.

The whole Working Group as well as each sub-team continued to meet monthly from November 2013 to March 2014 to complete the surveys, interviews, trials, and discussions. It presented the final report at APR March Meeting in Orlando, FL on 3/13/2014 on final findings, conclusions, and next steps.

The following sections are the contributions prepared by each sub-team for the Working Group's final report –

Industry Impact Sub-Team

Members include:

Jay Chilton – Clear Path Recycling

Curt Cozart – Common Sense Solutions

Dean Eberhardt – MRC Polymers

Jim Kulp – Clean Tech

Chip Lavigne – Allan Company

Lou Tacito – Plastics Forming Enterprises.

Discussion:

The initial thoughts were that the team would create a questionnaire, sent it to the recyclers and use it to report costs. However, it quickly became evident that the process would be much more complicated than that. With the diversity of our team we realized that each recycler was impacted differently. As we discussed this we came to the conclusion that two items affected how a recycler would be impacted by shrink sleeves: their material source (curbside, deposit, or expanded bottle bill) and whether or not they had a whole bottle wash. It made sense that the biggest percentage of shrink sleeve bottles would be in curbside material and the least would be in deposit material but the amounts were not defined. We also found that processors with dry label separation were less affected than those with a whole bottle prewash. However, these dry front-end processors tend to be running older equipment. We knew that the vast majority of the recent investment was in whole bottle prewashing systems processing curbside material. This style system was purchased for these plants because of the advantages a whole bottle prewash provides with handling very dirty curbside material. These lines with the least tolerance for the shrink sleeve labels would be experiencing the highest percentage of them. We then sought to classify the industry by material type and front end type.

Investigating MRF and Logistics Effects: We realized that shrink sleeves could also impact the logistics and MRF communities so we initially sought to research this aspect as well. We quickly found that the MRF's we spoke to did not treat shrink sleeves any different than other bottles and were mostly unaware that there was any issue with them. Although we are sure there is an impact to the MRF's, particularly with the automatic sorters we did not have enough information to further investigate. Therefore, we put this research aside.

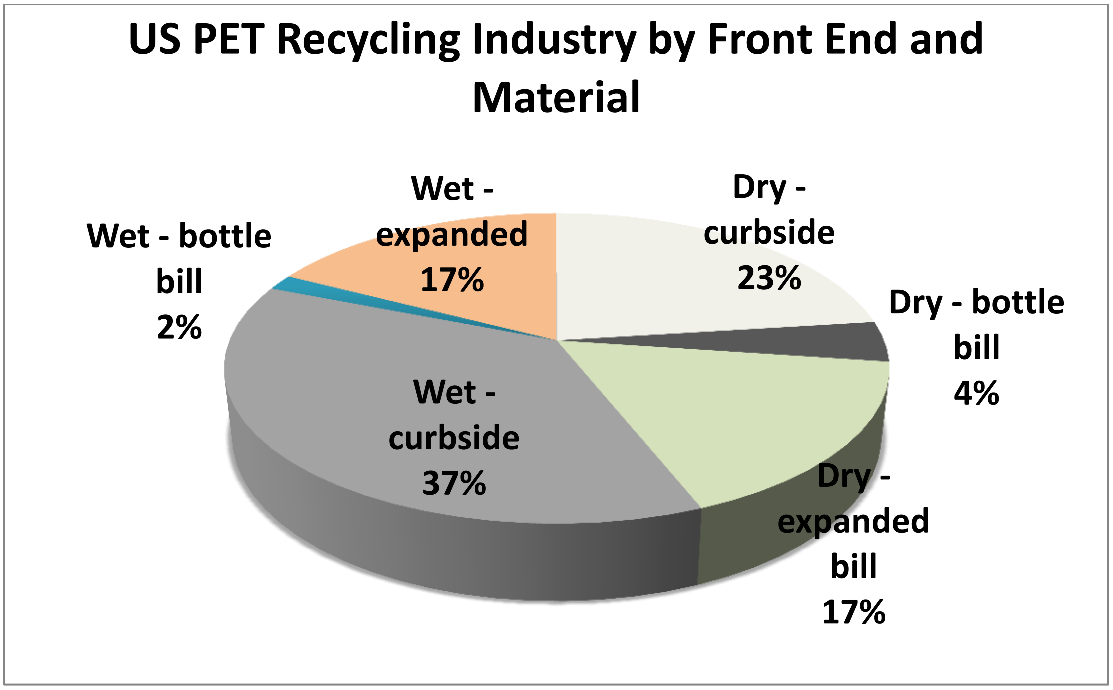
<u>Classifying by front end:</u> We started this process by listing all the processors in North America. We eventually decided to use only US plants and US material since it was difficult to classify material outside the US into our three categories. There was enough experience in the group to know what type of front end each processor used and, between published numbers and other knowledge to agree to an annual output for them. This allowed us to split the industry between dry and wet front ends. We had to make a second iteration of this when we learned one anticipated whole bottle prewash was not installed and another was purchased at a different plant.

<u>Classifying by material type</u>: Using the NAPCOR/APR report we found the total volume. We researched specific states to find deposit and expanded bottle bill numbers and were able to calculate percentages of each material type.

<u>Solving the Matrix:</u> We still needed a few of the matrix cells in order to solve for the other cells. We started with the very specific processors we knew who processed the majority of a material type. With this research we were able to calculate the following matrix and create the chart for 2012 data:

Year 2012	Dry front end	Wet front end	Total
Curbside	23%	37%	60%
Deposit	4%	2%	6%
Expanded BB	17%	17%	34%
Total	44%	56%	

1. Deposit = Bottle Bill requiring deposits for soda and beer bottles; some including water bottles.
2. Expanded BB = Expanded Bottle Bill requiring deposits for bottles of soda, beer, water, coffee, tea, juice, sports drinks, and other non-carbonated beverages.



It's important to note that these numbers are generated from industry data, team estimates and industry knowledge. They are intended to be indicative and should not be interpreted with strict precision.

Creating the Questionnaire: We quickly realized that many of the questions we needed answered would require data that many processors might not want to share. Therefore we developed a spreadsheet that provided the processors a data sheet wherein they placed their information and a submission sheet which used their data to give us non-confidential information that we required. They then saved the submission sheets as PDF's so we could not access the data and sent them to us. We assigned team members to be personal points of contact with the processors and asked APR Technical Director John Standish to review and sign an introductory letter explaining what we were trying to do. We selected recyclers from each category that we thought would have accurate information for us. Five out of the eight companies we contacted responded.

Responses: Not surprisingly, the companies most impacted by shrink sleeves were well represented in the responses. Companies processing expanded bottle bill material were also well represented. The biggest category of non-response was the dry front end processors processing curbside material. Interpreting the responses we realized that for the dry front ends and deposit and expanded bottle bill categories there was so much variation in process and business that it would be dubious to try to make conclusions from such a small sample size. Although these companies are not unaffected, they are not as affected as the wet front end companies processing curbside. We felt we had significant information to make some conclusions from the responders.

The following chart shows the ranges and averages for our responders:

INDUSTRY IMPACT TEAM CONSOLIDATED QUESTIONNAIRE RESPONSES

CALCULATIONS	***RESPONSES***	***COMMENTS***
Curbside	5.9%	Shrink sleeves average
Deposit, non-expanded bottle bill	n/a	Questionable responses
Deposit, expanded bottle bill	n/a	Questionable responses
Foreign import	0%	Unanimous
Do you track shrink sleeve labels in your incoming material?	Y and N	The more curbside you process, the more likely you are to track
Calculated Aggregate percentage of SSL's		Company specific
Do you blend bottles from all sources together rather than run them in campaigns?	Y and N	The more curbside you process, the more likely you are to answer yes
Do you treat shrink sleeved bottles any differently than a typical bottle?	Y	Unanimous
Do all bottles pass through machines you have installed specifically for SSL's?	Y and N	Process dependent
Calculated $/lb due to depreciation (5 year return)(if question above = Y)	0 to .01	
If you have not made any investment because of shrink sleeves, at what % do you think shrink sleeves would have to reach for you to make an investment?	0% to 10%	Company dependent
Calculated % SSL can reach before additional investment required	1%-12%	Company dependent
Calculated $/lb due to operating costs	.01 to .04	Business dependent

Does the presence of these bottles in your material reduce the quantity of material that would otherwise be fed to your grinders (bottleneck your sorters/equipment before grinding)?	Y	Unanimous
Calculated $/total output lb due to yield loss	.001 to .02	Business dependent
Calculated $/total output lbs due to quality issues from SSL's	0 to .01	Business dependent
Do you incur water treatment surcharges because of bleeding ink? (colored discharge)	N	Unanimous
Calculated $/total output lbs due to water treatment issues from SSL's	0	Unanimous
Total $/total output lb costs/losses due to SSL's	.001 to .04	Business dependent

General survey Results (for all responders):

- **Material:**
  - Shrink sleeve labels are primarily concentrated in curbside material (4-7%)
  - Shrink sleeve labels also exist in expanded bottle bill and deposit material in lower amounts
- **Processors:**
  - Are more likely to track shrink sleeve label percentages if they process curbside
  - Unanimously treat shrink sleeve labels differently than other bottles
  - Process shrink sleeve labels in both main stream and side stream processes
  - Differ in process toleration of shrink sleeve labels (0-12%)
  - All have yield loss due to shrink sleeve labels
- **Costs due to SSL's:**
  - < $.01/lb for machine depreciation
  - $.01 - $.04/lb for operating costs for shrink sleeve label specific machines/labor
  - $.001 - $.02/lb for yield loss
  - < $.01/lb for final quality
  - Bleeding ink was not measured

(lbs = total output lbs of the processor, not just the output lbs of sleeved bottles)

Costs to recyclers with wet front ends processing curbside material: (37% of the industry).

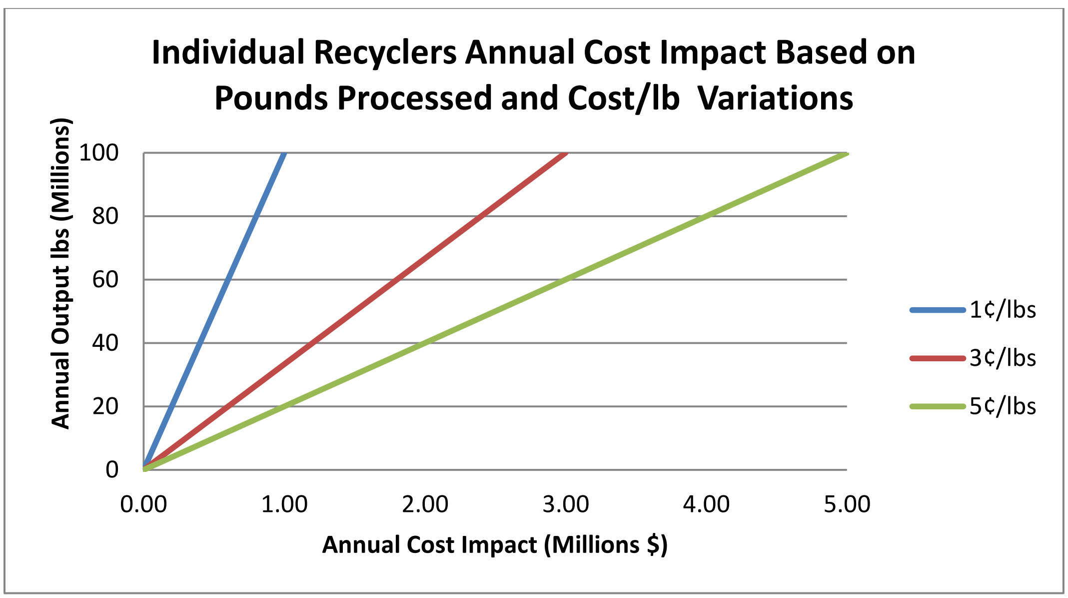
- $.001 -$.01/lb for machine depreciation, depending if they have purchased machinery for shrink sleeve labels or not.
- $.01 - $.04/lb for operating costs for shrink sleeve label specific machines/labor
- $.01 - $.02/lb for yield loss

- < $.01/lb for final quality
- Bleeding ink was not measured
- $.02 - $.045/lb - total cost of SSL's to each processor

(lbs = total output lbs of the processor, not just the output lbs of sleeved bottles)

Total Impact: It is important to note that every single responder reported a cost due to shrink sleeve labels. As previously mentioned, the sample size does not allow us to accurately measure a large segment of the industry (dry front ends, deposit and expanded bottle bill processors). With the exception of the dry processors running curbside material who tend to be very similar, these recyclers are so diverse in their processes that the only accurate way to measure the impact would be to survey the entire industry. With that said we were able to sample a significant portion of the **wet-curbside industry** and calculate their costs. These ran between **$.02 and $.045 for every pound of finished product** they made. The lowest cost reported for any responder from any category was $.001.

The chart below depicts total annual cost to a recycler based upon his cost per pound and size of plant.



Bottle Sorting Sub-Team

Introduction

The APR Full Sleeve Label Working Group has a team focusing on the impact of labels on NIR and color sorting. This team meets regularly by conference call. This team consists of the following members

- Dave Hill – Jindal Films
- Matthias Erdmannsdoerfer – NRT
- Robby Parrish – NRT
- Weilong Chiang – PepsiCo
- Kristi Hansen – PFE

Recently the sorting subgroup developed a survey for 6 leading sorting equipment suppliers, and requested them to run a trial on shrink labeled bottle samples. The 6 selected suppliers consist of the following companies

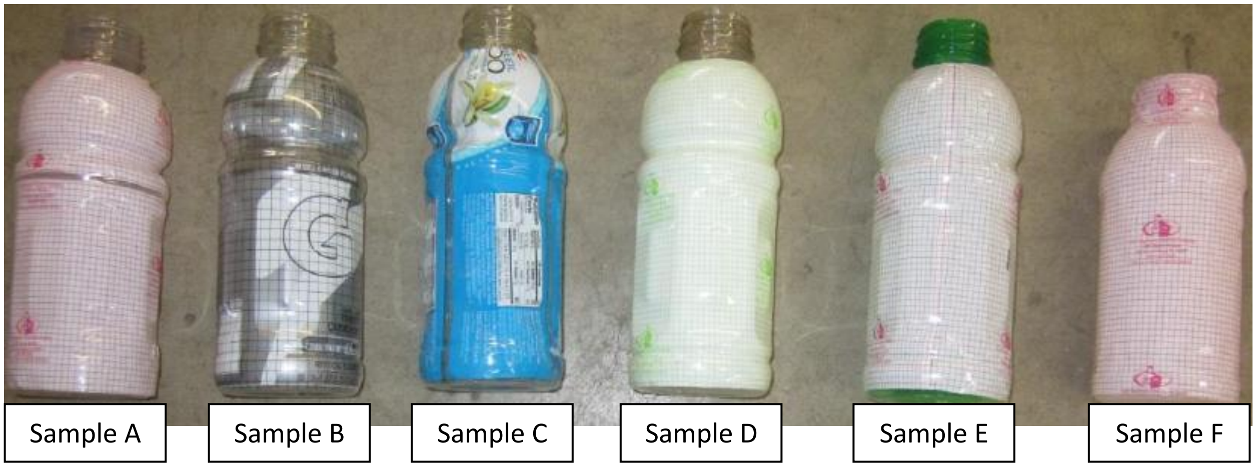
- Pellenc
- MSS
- NRT
- TiTech
- S+S
- Steinert

The **survey** was sent to the 6 suppliers of the sorting equipment to create an understanding of what equipment is in use today, and what the capability of that equipment is when shrink sleeve labels are used on PET bottles. All of the equipment suppliers responded to the survey willingly.

The **trial** request was also well received and all 6 leading suppliers completed the requested trial in detail.

Six different bottle/label combinations had been sent to the 6 labs for equipment capability evaluation.

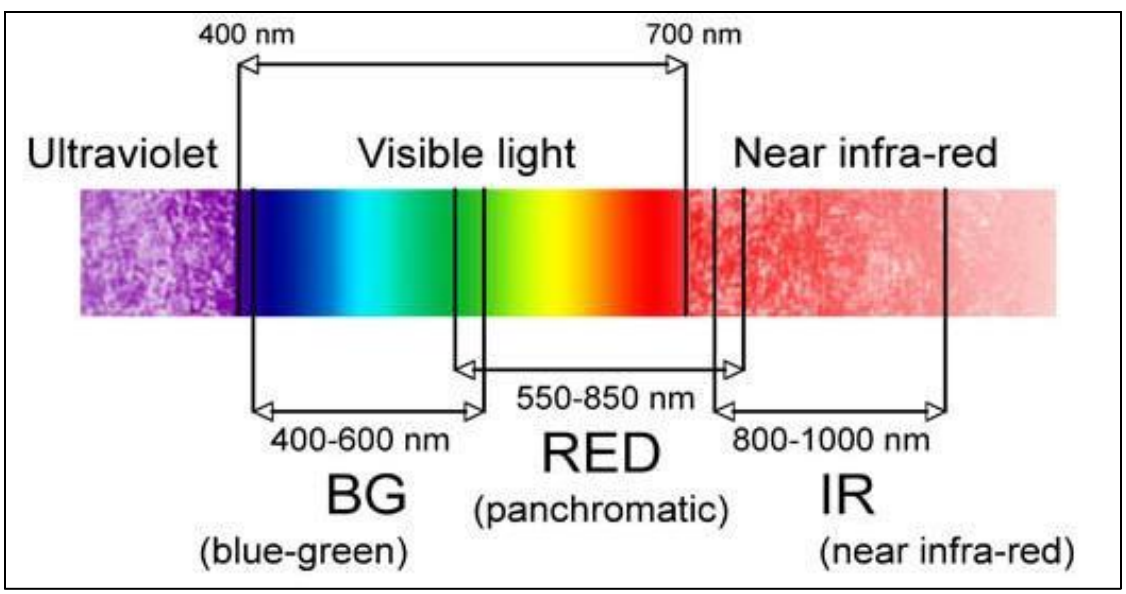
- Sample A – PETG (Applied to Clear PET Bottle)
- Sample B – Polyolefin #1 (Applied to Clear PET Bottle)
- Sample C – Polyolefin #2 (Applied to Clear PET Bottle)
- Sample D – OPS (Applied to Clear PET Bottle)
- Sample E – PETG (Applied to Green Bottle)
- Sample F – PETG (Applied to HDPE Bottle)



General basics on NIR and Color spectroscopy and sorting of PET bottles

The equipment and software used on today's color and NIR (Near-Infrared) sortation equipment is very sophisticated. Each supplier has developed its own proprietary approach that employs NIR and color spectroscopy; some suppliers might employ a color camera to evaluate the image of a bottle to evaluate color. Proprietary elements of the equipment and software influence the effectiveness of the equipment and those who are not experts may not fully understand how the equipment performs.

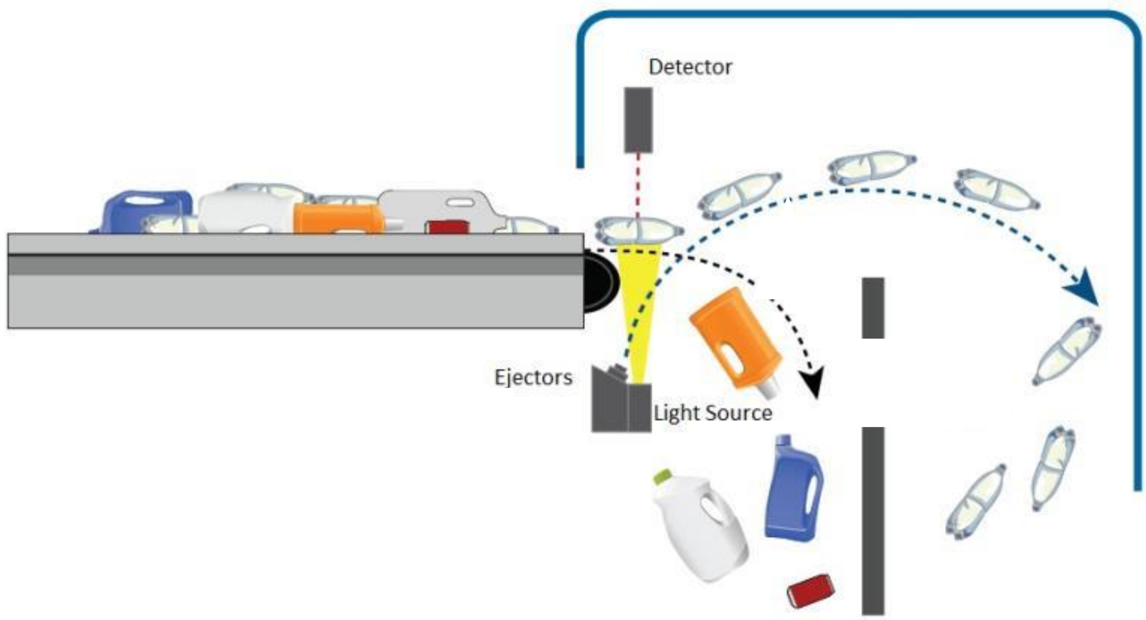
Understanding the basic elements of spectroscopy is available and does help create a first pass understanding of variables that a full sleeve label on a PET bottle might impact.



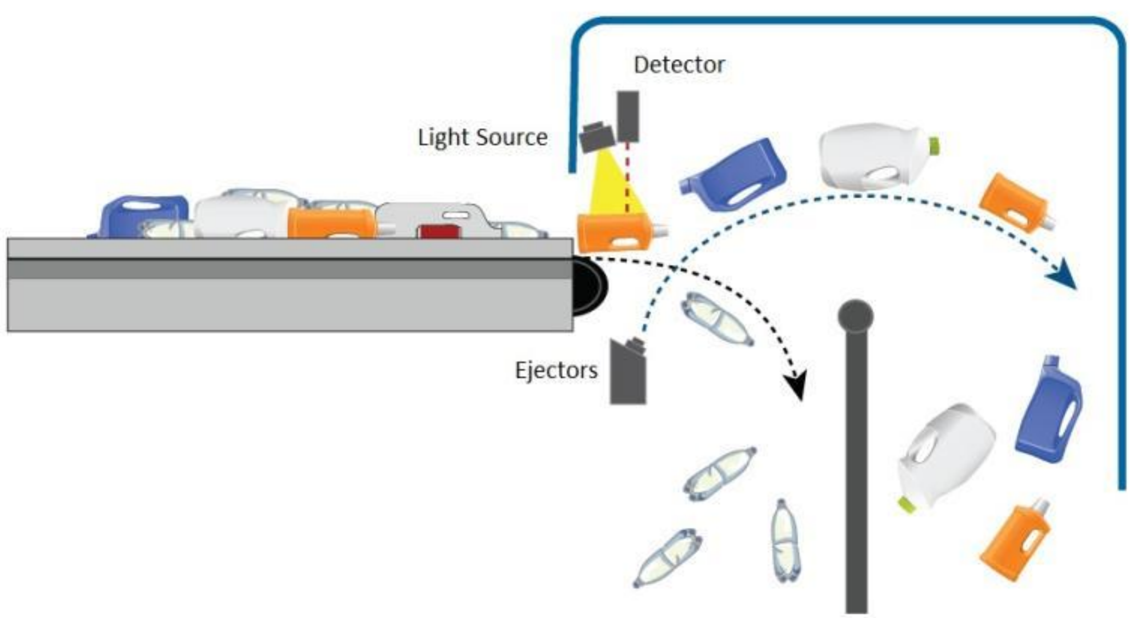
In NIR or color spectroscopy, a sample is illuminated with an energy source. The energy source might be an incandescent light, quartz halogen light or an LED, for example. In reflectance mode, a detector collects the energy that reflects off of the sample over a range of wave lengths. For optical (or visible) spectroscopy, that wave length range is 400 to 700 nm, the range of the visible light spectrum. NIR covers from 800 to 1000 nm and even up through 2000 nm, a range of wavelengths just above the visible range.

Spectroscopy can also be conducted in transmission mode where a detector evaluates the energy transmitted through a sample.

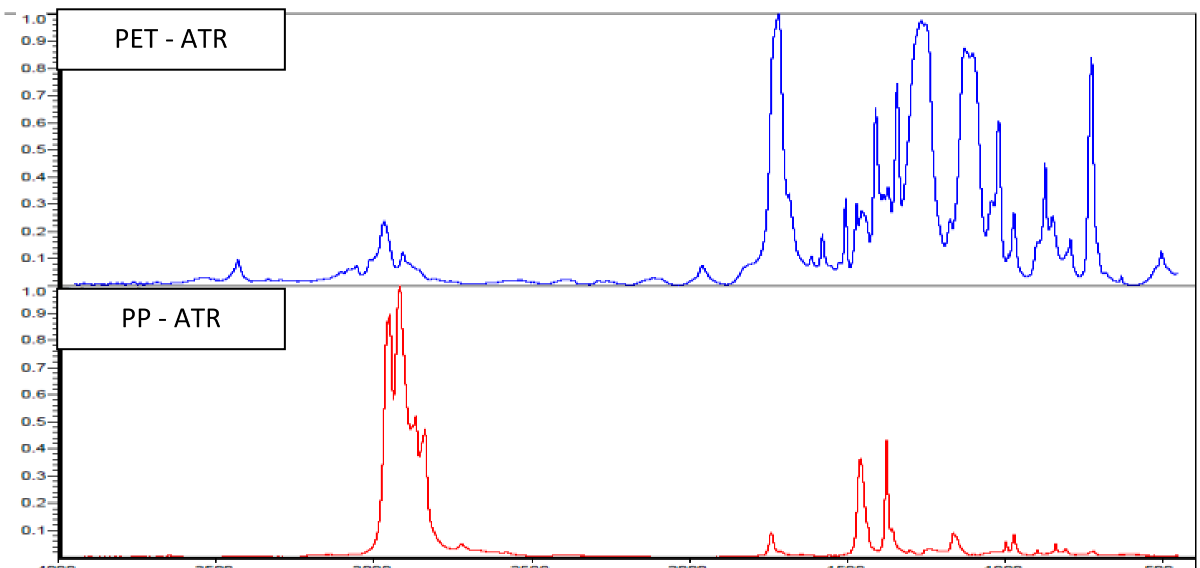
Transmissive Image



Reflection Image



A given color has a characteristic spectrum. For example something that is blue in color absorbs longer yellow and red wave lengths and reflects or transmits the shorter blue wavelengths of light. Many plastics have a characteristic NIR reflection/transmission signature/trace that can be used to distinguish, for example, **PET from PP**, or PVC from PET. Computer software is used to analyze the reflection or transmission spectrum to identify the sample and determine whether it is left on the conveyor or ejected.



In the case of reflection mode when a full sleeve label is used, the detector sees a reflected signal that is a mixture of energy reflected from the layers of label stock and the PET bottle. In the case of transmission mode, the detector sees the energy remaining after transmission through layers of both label and PET bottle. The detectors have the best discrimination when there is a good “signal to noise” ratio. If a given sample is highly reflective, highly absorbing, or scatters energy so that it does not reach the detector, there will be a poor signal to noise ratio.

The survey results below indicate that cameras capable of color detection are also used to assess the color of PET bottles and labels. It will be helpful for stakeholders to better understand and compare the benefits of camera and spectroscopy methods for label and bottle color detection.

Some key label variables will include:

Label characteristic	Possible impact on NIR sort	Possible impact on color sort
An opaque label with high loading or thickness of TiO2 pigment used in the ink.	TiO2 reflects NIR energy. Under laying PET bottle not seen in reflection. In transmission, detector sees bottle as opaque.	Bottle is seen as a white bottle and sorted into colored stream.
Aluminum metallic pigment used in ink	Aluminum pigments are highly reflective and results may be as with TiO2.	Bottle seen as opaque.
A carbon black pigment used in ink	Carbon black pigment in the ink is highly absorbing of energy; the bottle may not be detected by NIR.	Bottle will be seen as an opaque bottle.
Label has blue or violet color as predominant shades		Many color sorters are set up to pass blue colored PET bottles; these blue labeled bottles may be passed by the color sorter.
Label has large clear areas that do not have printing	NIR unit readily sees bottle as PET	Color sorter sees bottle as clear and passes it as not colored.
Label is relatively thick compared to the bottle wall thickness	Instrument detects the label, but may not see the bottle wall in reflection.	

In addition, the sorting equipment results may be impacted by the condition of the bottle:

- Inflated round bottle compared to a flattened bottle from a bale. Light will reflect and transmit differently from flat vs. round conditions. Air gaps between label and flattened bottles can allow scattering of light.
- A bottle directly from a bale compared to a bottle from a whole bottle wash – the wash will clean the bottle, and the label may shrink changing the relative thicknesses of the label and bottle wall.

Survey results - Questions Impacting NIR Sortation

1) NIR: Reflection and/or Transmission? Please describe your technology. [The following entries are answers provided by responders.]

- The technology combines the advantages of reflection and transmission sensing. As shown in the figure below, a light source illuminates the material traveling through the sensing zone. If an item is opaque, the light reflects directly off the surface into the NIR + Color scanner, therefore behaving like a reflection sensor. If the item is transparent or translucent, the light goes through the items and is reflected off a white reference, which directs the light back through the items and into the NIR + Color scanner, therefore behaving like a transmission sensor. Especially for sorting of transparent PET bottles, this technique has significant advantages over purely reflective or purely transmissive sensor systems.
- Reflection: The camera and the lights are both fixed over the bottle stream. The light is reflected from the bottle and is analyzed by the camera.
- Reflection only
- We produce both transmission and reflective NIR technologies. Both imaging systems use highly sensitive spectrometers to determine polymer type. We typically specify transmission technology for the rPET industry due to highly accurate identification from transmitting the light signal through two layers of container polymer.
- The latest technology pairs an Infrared Camera with a lens specially design to filter the IR wave length we get best possible signature with less hardware and minimal needs of light projection. This technology work in reflection mode
- The technology uses lighting and detector above the belt but we pass the light through the material before returning to the detector.

Conclusions to Question 1

Three suppliers offer reflection only. One supplier offers both reflection and transmission operating separate/single mode. Two suppliers offer equipment that evaluates components of both reflected and transmitted light in the sort determination.

1a) Reflection: What is your experience with full sleeve labels? Is your equipment able to reliably detect label polymer and/or underlying bottle polymer? If Yes, please also provide efficiency in percentages (such as 75% or 95% and so on). [The following entries are answers provided by responders, in random order from those in Question 1.]

- PET-G : 95% +, ** depends on the film thickness. Polyolefin : 95% +. OPS : no experience at the moment, to be tested with your sample. Underlying bottle polymer with PET-G and POs film, our experience demonstrate that we obtain a mix signature that can be used to include or not the bottle itself in the sort path.
- Good detection rate, good distinction of the labels. Efficiency about 80-95 %
- PETG full sleeve labels: If the label is snug to the PET bottle we cannot see the PETG label, the sorter thinks it is PET. If the label is lifted from the bottle it can see the PETG (label) but of course not the bottle underneath (PETG full shrink sleeve after bottle wash). PP, PS, PLA, PVC or any other full shrink sleeve label which is easy to distinguish from PET in NIR: >95% detection rate if the shrink sleeve is snug to the PET bottle.
- >80% detection of bottle polymer. <20% detection of label polymer.
- With the combined methods as described above, we can reliably detect the full sleeve label material. The underlying bottle polymer can be detected if the print on the label is not too opaque. If the label has heavy printing on it, we can't see the bottle polymer. Some suppliers claim they can reliably identify the bottle polymer but we haven't heard from any reclaimer/recycler confirming that this truly is the case.
- We are able to tell there is a label on a PET bottle. The underlying polymer is readable. We can always read a label on the bottle and in most cases can make the difference between the different label polymers.

Conclusions to Question 1a

Results vary in both capability % and operation. For illustration, one supplier indicated that 95% of the time they can distinguish a PO or PETG film over a PET bottle, and identify both the label and the bottle composition. One supplier cautions that film thickness of the label is a factor that can diminish identification accuracy.

A second supplier indicated greater than 80% effective at identifying the PETG bottle polymer, but only 20% effective at identifying the PETG label polymer on a PET bottle.

1b) Transmission: What is your experience with full sleeve labels? Is your equipment able to reliably detect label polymer and/or underlying bottle polymer?). [Answers from responders are in random order from those in Question 1 and 1a.]

- N/A
- N/A
- N/A
- Same answer as 1a.
- >85% detection of PETG bottle polymer. <15% detection of PETG label polymer on a PET bottle.
- OPS, PO, PVC labels on PET bottle 95% detectable. PETG labels 80% detectable on a PET bottle.

Conclusions to Question 1b

Similarly wide response; one supplier reports 85% effectiveness determining the PET bottle in transmission and only 15% effectiveness identifying the label composition. Another supplier reports 95% effective identification of OPS, PP, and PVC labels on PET, and 80% effective when the label is PETG.

2) Can you reliably distinguish between PET and PET-G for bottles? For labels? What polymer "signature" do you get from a PET bottle with a PET-G label? [Answers from responders are in random order.]

- Yes, for further details supplier consent required.
- PET bottle vs. PETG bottle -> good. PET bottle with PETG label -> not possible -> PET signature
- PET and PET-G bottles: Yes. CHDM (CYCLOHEXANEDIMETHANOL) levels in PET-G bottles/objects need to be sufficiently high to detect it. We do not know what level of CHDM is the limit (if you can provide samples with different CHDM levels it would be most appreciated). For those that have enough CHDM so we can detect it efficiency is >93%. PET-G labels on PET bottles: See 1 a)
- 90%+ accuracy of determining PET containers from PET-G containers. We typically identify a PET container with a PETG label as PET. Occasionally a thin walled PET container with a thick PETG label will deliver a PETG signature.
- Both (PET and PETG) polymers can be clearly distinguished. Signature is different enough. For PET bottle with PET-G label, as mentioned above, we obtain a mix signature that can be incorporate in the sorting matrix.
- Yes between PET bottles and PETG bottles. There are no PET labels (only PETG labels) to our knowledge. We see a difference based on our spectrometer reading on the two bottles.

Conclusions to Question 2

Majority of responses stated that the PETG bottles can be detected separately from the PET bottles. The PETG label on a PET bottle has a more challenging detection. The PET trace vs. the PETG trace is very similar and it depends on the equipment technology for capability for separation.

3) What polymer "signature" do you get from a PET bottle with a Polyolefin label on your equipment? [Answers from responders are in random order.]

- As discussed under 1a), it depends on how heavily printed the label is. If it's lightly printed, we can detect both the label polymer and the bottle polymer. If it's heavily printed we will only see the label polymer.
- Same as 2.
- Mixed spectrum of the two polymers, which can be classified as PET bottle with a PO label.
- We see an "averaging" of the spectra. The PET absorption peaks are muted compared to a PET container without a label and the Polyolefin absorption peaks are slightly noticeable. This all depends on thicknesses of the container and thicknesses of the label, but we mostly identify the underlying PET bottle.
- A mixed signature of PET and PO – as long as the PO is thin enough and snug to the PET bottle.
- We get a mixed signal between PET and Polyolefin. This signature can be a reliable signature to distinguish between PET and Polyolefin.

Conclusions to Question 3

Responses for this question were more uniformly that a mixed signal of PET and PO was obtained that allowed a PO film to be seen on a PET bottle. Responders cautioned that a high level of printing ink can prevent detection of the PET bottle under a PO film, and that if the label was not tight to the bottle, the underlying PET bottle was less likely to be detected.

<u>Survey results - Questions Impacting Color Sortation</u>

4) Color: Reflection and/or Transmission? Please describe your technology. [Answers from responders are in random order.]

- Same answer as under Question 1. Our sensor technology identifies NIR + Color signature all at the exact same time in the same scanner unit. There is not a separate NIR sensor and color camera.
- Transmission: The camera is fixed over the bottle stream. While the bottles are in free fall, the light appears from the bottom upwards through the bottles and is analyzed by the camera.
- Reflection only.

- We can use both transmission and reflection. For the rPET industry, transmission is preferred to avoid identifying the color of the label. In transmission the label will not pass light and therefore look opaque in the label regions. We can recognize the small portions of a full sleeved bottle that are not covered by label, i.e. base and neck, to determine the base polymer color. With image recognition software, we are able to eject on the whole bottle and not just the portions of the bottle that visible to transmission light.
- We use CMOS (complementary metal-oxide semiconductor) camera in transmission mode.
- Reflection. Same as NIR and looking at the same pixel. Using visible spectroscopy. It is much more color detailed than RGB color and more robust on dust and darker materials.

Conclusions to Question 4

This question seems simple, but the answers were very mixed. Some use reflection and others transmission. Some refer to using spectroscopy to analyze for color, but others refer to using cameras and image detection software to characterize color and distinguish between the color of the label, and the color of the underlying bottle.

5a) Transmission: How much bottle "coverage" by the label is acceptable and you can still reliably identify the underlying PET bottle by color? [Answers from responders are in random order.]

- As discussed above, the color/ink density on the label plays the biggest role in reliable detection of the underlying polymer. Furthermore, it also depends on the software sensitivity settings to at what point is a bottle identified as a different color/material than the label. For example, if those settings are set really sensitive, only 1 in 2 of visible PET bottle color is sufficient to sort it correctly. If the parameters are set very relaxed, it may take 10 in 2 to make it a positive identification.
- 100 % label -> Camera can only see the color of the label and for this classifies the bottle as "colored".   80 % label -> If 20% or more of the bottle under the label is visible, we are able to ignore the label and only detect the bottle underneath.
- We only use Reflection.
- Approximately 10%.
- If we positively sort clear PET we can tolerate up to 80%. If we positively sort color PET, it is more like 50%.
- No Data.

Conclusions to Question 5a

Responses indicate that in range of at least 10 to 20% of the PET bottle needs to be visible without label to be reliably identified as clear PET.

5b) Would you use reflection mode in a PET stream? If yes, how do you distinguish between label color and bottle color (when the same)? [Answers from responders are in random order.]

- No.
- We only use reflection. We can measure opacity which we use as a feature to remove full shrink label bottles (with PETG labels).
- We would not use reflection-only for color sorting of PET bottles. Besides the less than ideal identification of label colors vs. bottle colors, reflection identification doesn't work well for sorting of dirty clear bottles from very light blue bottles. In the US, those really light blue bottles are not that popular but it's a totally different story in Europe.
- Yes. (1) Through the spectrum of the color. (2) By coupling with NIR by recognizing the different material.
- No.
- No, reflection would generate too much of material losses.

Conclusions to Question 5b

Determining color of the underlying bottle is difficult in reflection mode when a large label is present.

Survey results – Additional Questions Impacting Sortation

6) Do you have test equipment that can simulate a production run on sample bottles? Have you done tests with full sleeve labels (if yes, can you share)? [Answers from responders are in random order.]

Conclusions to Question 6

All six respondents have laboratory test equipment that can be used by the industry. Results are not available as they have been completed for customers directly and results are proprietary with the exception of work previously done directly for APR in 2012.

7) What problems do you see in the field when dealing with sleeve labeled bottles? What feedback/problems do you get from your customers? [Answers from responders are in random order.]

- See above comments re: heavily printed labels, those definitely cause the most problems. Also, if they would not cover the complete bottle that would make it much easier.

- Difficult color separation and PETG Label identification. Customers complain about loss of good material and higher contamination due to labels which cannot be removed.
- My customers have three outlets on their sorting: Clear PET, Green or Color PET, and non-PET. I can put most of the full sleeve labeled bottles into any of these streams (some easier than others) but they create an issue everywhere unless the label is stripped off or they are collected and processed separately.
- MRF Industry Positive ID PET. Labels obscuring the PET spectral signal of thin walled PET bottles. rPET Industry Positive ID PET. Some processors want to remove F.S. PET container and some want to leave it in stream. Labels obscuring the PET spectral signal of thin walled PET bottles. Small regions of open areas without label for color identification
  rPET Industry Positive ID Contaminates and Eject. Labels can obscure PET signals and cause removal of PET container due to label polymer. Some processors want to segregate the Polyolefin containers from the PET which could cause ejection of a Polyolefin label on a PET container. The problematic sleeve is generally the ones that are full glued on the bottle. This type of sleeve gets very difficult to properly identify. Other than that it is pretty easy application.
- Some sleeved bottles may be ejected with colored bottles.

Conclusions to Question 7

List of comments includes:

- Heavily printed labels obscure NIR signal of under laying bottle.
- Complete coverage of label obscures color detection of under laying bottle.
- With a NIR and a color sorter – the sleeved bottles most often get directed to the colored stream where additional sorting is needed.
- If the NIR unit detects the label and not the PET bottle, a good PET bottle can be rejected.
- Full wrap-around pressure sensitive labels are also a problem.

8) Are you working on any developments addressing full sleeve labels? Any other thoughts/experience you want to share? [Answers from responders are in random order.]

- No additional comments at this time.
- More and more customers are facing such problems. That's the reason why we are constantly working on new solutions.
- No however, many users in Europe had us work on advanced machine setting to address similar issue and we did achieve satisfying results with our standard technology.
- PET-G, PVC, PLA and all sinkable full shrink labels: Sorting them is not that much of a problem for us. Problem for the customer is that his wash line cannot remove the sinkable label so he has to get it off before it gets to the wash line. Floatable labels such as PO
  Sorting them can be an issue if the reclaimer does not use a bottle wash which removes the glued-on labels. If you have programmed your sorter to put everything that has a PO+PET signature forward in the clear PET it will get confused and make mistakes with other colored

bottles that have PO labels, when processed in the color sorter following the polymer sortation. In general we will have an issue with color sorting on full shrink sleeve bottles: We cannot see the color underneath the sleeve, no matter what material the sleeve is made of. Who guarantees us that all bottles under the sleeve will be clear PET? Unless the sleeve gets removed by the label remover and we pass it again through the optical sorter, there is no way to make sure.

- We recently have improved our Vision spectrometer last year and we continue to improve the technology each year in order to stay ahead of the needs of our clients.
- We have recently developed enhancements (Patent Pending) to more reliably identify PET that is covered with full sleeve labels, thin walled PET and PET containers that contain liquids. The gains in capturing the PET bottles with full sleeved labels of different polymers are below.
  • Detection of PETG labeled PET bottles is 100% with or without enhanced system.
  • Detection of polyolefin labeled PET bottles increased by 2x with enhanced system.
  • Detection of PVC labeled PET bottles increased by 1.3x with enhanced system.
  • Detection of PLA labeled PET bottles increased by 1.7x with enhanced system.
  • Detection of OPS labeled PET bottles increased by 8x with enhanced system.

Conclusions to Question 8

Most suppliers have on-going efforts to improve the response and capability of their equipment.

One responder commented that sortation equipment had the capability to identify label material and color of the PET bottles, but this capability alone does not solve the problems that sleeve labels cause recyclers. Examples given are that sinking labels such as PETG, PVC, and OPS still need to be removed from the bottle. And where a PO label can be seen on a PET bottle, but it may not be known whether the bottle is colored or clear.

6) Theoretically, if my equipment was installed in January of 2012 or before will I need…
A - Software Upgrade Only, B - Equipment Upgrade Only, C -Both Software and Equipment Upgrade, to accomplish the results seen on lab reports at the best results? [Answers from responders are in random order.]

- It would require both, new equipment hardware + software. The reason is that we didn’t have the current technology available at that point in time.
- Answer is: A.
- Only Software upgrade might be required.

Polymer Positive and Negative Sortation Trial Results

Polymer Sortation Test Procedure

- Mix 50 shrink-labeled bottles of Samples A, B, C, D, and F together, and comingle them as randomly as possible.
  - Sample A – PETG (Applied to Clear Bottle)
  - Sample B – Polyolefin (Applied to Clear Bottle)
  - Sample C – Polyolefin (Applied to Clear Bottle)
  - Sample D – OPS (Applied to Clear Bottle)
  - Sample F – PETG (Applied to HDPE Bottle)

- Run all 50 bottle mix through the NIR sortation equipment under the manufacturer-recommended operating condition.

- Collect the bottles being identified by the NIR sortation equipment as PET bottles, and those not identified as PET bottles. Physically count the numbers of bottles for each label polymer (film substrate) type, and calculate the accuracy percentage.

<u>Trial 1</u> Reflective and/or Transmissive mode, positive sort

<u>Trial 2</u> Reflective and/or Transmissive mode, negative sort

R = Reflection

T = Transmissive

P = Positive

N = Negative

SPET = Software change for PET

SShrink = Software change for Shrink

--- = Did not run the variable

(orange)	100% Accuracy
(yellow)	50-90% Accuracy
(pink)	0-40% Accuracy

	Polymer Trial 1 Positive Sort Seen as PET Bottle				
Sorter	**A**	**B**	**C**	**D**	**F**
1 - R - P	10	10	10	10	0
2 - R - P	10	10	10	10	0
3 - R - P	10	10	10	10	0
4 - R - P	10	2	2	7	0
4 - R - P - SPET	10	10	5	10	0
4 - T - P	10	10	10	10	0
5 - R - P	9	1	0	0	0
5 - R - P - SPET	6	6	0	1	0
5 -R - P - SShrink	10	10	10	10	0
6 - R - P	10	10	10	10	0

	Polymer Trial 2 Negative Sort Seen as PET Bottle				
Sorter	**A**	**B**	**C**	**D**	**F**
1 - R - N	10	10	10	10	2
2 - R - N	10	10	10	10	0
3 - R - N	---	---	---	---	---
4 - R - N	10	10	10	10	1
4 - R - N - SPET	10	10	9	10	3
4 - T - N	10	10	10	10	0
5 - R - N	0	0	3	10	0
6 - R - N	10	10	10	10	0

Color Positive and Negative Sortation Trial Results

Color Sortation Test Procedure

- Mix 30 full-wrapped shrink-labeled bottles of Samples A, E and F together, and comingle them as randomly as possible.
  - Sample A – PETG (Applied to **Clear** Bottle)
  - Sample E – PETG (Applied to **Green** Bottle)
  - Sample F – PETG (Applied to **HDPE** Bottle)

- Run all 30 bottle mix through the color sortation equipment under the manufacturer-recommended operating condition.
- The output of the color sortation is divided into 1) clear bottle stream, 2) green bottle stream, and 3) opaque bottle stream. (Note: At operator's discretion, opaque bottles can go with clear bottle stream, or green bottle stream, or opaque bottle stream by itself.)

- Collect the bottles in each stream separated by the color sortation equipment. Physically count the numbers of bottles in each stream, and calculate the accuracy percentage.

R = Reflection

T = Transmissive

P = Positive

N = Negative

SPET = Software change for PET

SShrink = Software change for Shrink

--- = Did not run the variable

(orange)	100% Accuracy
(yellow)	50-90% Accuracy
(pink)	0-40% Accuracy

		Color Trial Positive See as Accurate Bottle		
		Clear Bottle	Green Bottle	HDPE Bottle
Sorter	**% Tested**	**A - w/Closure**	**E - w/Closure**	**F - w/Closure**
1 - R - P	---	---	---	---
2 - R - P	**10%**	10	10	10
3 - R - P	**0%**	10	10	10
4 - T - P	**0%**	10	10	10
5 - R - P	**---**	---	---	---
6 - T - P	**20%**	8	10	10

Trial 3-9 reflective and/or transmissive mode, labels remove in 10% increments. At best results include closure for evaluation of PET thread coverage.

	Color Trial Positive Sort See as Accurate Bottle					
	Clear Bottle	Green Bottle	HDPE Bottle	Clear Bottle	Green Bottle	HDPE Bottle
Sorter	**A - 0%**	**E - 0%**	**F - 0%**	**A -10%**	**E - 10%**	**F - 10%**
1 - R - P	10	8	10	10	10	9
2 - R - P	10	10	10	10	10	10
3 - R - P	10	10	10	10	10	10
4 - T - P	10	10	10	---	---	---
5 - R - P	0	0	---	0	0	---
6 - T - P	0	3	10	3	5	10

	Clear Bottle	Green Bottle	HDPE Bottle	Clear Bottle	Green Bottle	HDPE Bottle
Sorter	**A - 20%**	**E - 20%**	**F - 20%**	**A - 30%**	**E - 30%**	**F - 30%**
1 - R - P	---	---	---	---	---	---
2 - R - P	10	10	10	10	10	10
3 - R - P	10	10	10	10	10	10
4 - T - P	---	---	---	---	---	---
5 - R - P	0	0	---	0	0	---
6 - T - P	10	10	10	---	---	---

Sorter	Clear Bottle A - 40%	Green Bottle E - 40%	HDPE Bottle F - 40%	Clear Bottle A - 50%	Green Bottle E - 50%	HDPE Bottle F - 50%
1 - R - P	---	---	---	---	---	---
2 - R - P	10	10	10	10	10	10
3 - R - P	10	10	10	10	10	10
4 - T - P	---	---	---	---	---	---
5 - R - P	4	3	N/A	5	5	---
6 - T - P	---	---	---	---	---	---

Sorter	Clear Bottle A - 60%	Green Bottle E - 60%	HDPE Bottle F - 60%	Clear Bottle A - 70%	Green Bottle E - 70%	HDPE Bottle F - 70%
1 - R - P	---	---	---	---	---	---
2 - R - P	---	---	---	---	---	---
3 - R - P	---	---	---	---	---	---
4 - T - P	---	---	---	---	---	---
5 - R - P	8	9	---	9	10	---
6 - T - P	---	---	---	---	---	---

Survey and Trial Conclusions

Survey Conclusions

- The reflection vs. transmissive technology does not show one more favorable than the other for successful label separation. Each Technology has beneficial contributions.
- Equipment can be designed to separate by label polymer with the exception of PETG. The challenge still lies with the color sortation.
- Film thickness, bottle shape from baling, and tightness to bottle can challenge some equipment capability.
- PET bottles vs. PETG bottles are not as concerning to separate as attempting to separate PET bottles from PETG labeled bottles.
- Technology does not differ for color sortation for most suppliers when looking at color vs. polymer. There are a few additional methods in sorting color.
- Coverage % does have an effect for some suppliers. 10-20% PET bottle exposure is suggested to design labels for bottles.
- Ink Pigments, ink coverage, and color can affect the capability of acceptance or removal.
- There is a continuous effort on upgrading technologies to separate more acutely when working with full sleeve labeled bottles.
- The continuous improvement for sleeve label separation is software upgrades. There are some suppliers that will require equipment change for best results.

Polymer Trial Conclusions

- Polymer sortation with shrink sleeve labels has surprising results. The labels applied to the bottles with various materials and ink design were able to be seen as PET bottles.
- Two suppliers specifically identified the software change to accommodate the PET bottle stream.
- One supplier specifically identified a software change to accommodate the sleeve label stream on PET bottles.

Color Trial Conclusions

- It was not evident that reflection vs. transmissive had negatively impacted the outcome of the results.
- 20% exposure of PET bottle shows all but one suppliers separating accuracy at 100% success.
- With or without closure, the 20% exposure of PET bottle still is true for the suppliers that completed this trial.

Label Removal Sub-Team

Team Members

- Curt Cozart
- Michel Gosselin
- Jeff Meyers
- Frank Schloss
- Carl Williams

Objectives

- Survey and describe the functionality of de-labelers offered by leading equipment vendors.
- Solicit suggestions from equipment vendors to determine if they offer any devices that would improve the functionality and effectiveness in removing shrink sleeve labels from PET flakes?

Content

1) Label removal equipment survey

2) Dry grinding shrink label separation technologies

3) Request for solution letter

1) <u>Label removal equipment survey</u>

Some Context & Background

<u>Operating Overview</u>

De-label machines use mechanical means to rip or tear labels off of PET bottles. A general approach is that some combination of metal pins and blades are used to tear the label from the bottle while the bottle passes between a stationary and a rotating drum.

The gap between the drums and the gap between blade and pins influences the efficiency of removal. The dimensions of the bottle in terms of both volume of the bottle, and whether it is crushed from baling or loose, are likely to also have an influence on label removal.

Because there are rotating parts, there is wear inside this kind of machine and wear parts must be changed at some maintenance period. The rate of wear will be influenced by the throughput of the machine along with rotational speed coupled with the gap settings.

If the gaps are kept small to provide best label removal, there is a likelihood of creating “broken necks” where the neck and finish of the PET bottle is entirely separated from the bottle. After bottles exit the machine, provision must be made to separate labels from bottles, and not lose the PET resulting from broken necks.

Sizing the Unit

Individual PET reclaimers may use a de-label machine in different configurations depending upon preference and requirements of a given site. In one case, all bottles might be sent through the de-labeler so that bottles are presented to auto-sorting and manual sorting with a minimum of interference from labels. But others might chose to position the de-labeler after a sorting step so that only those bottles with labels, or only those bottles identified as colored bottles by the auto-sortation machines, go through the de-labeler, and are then passed back to the beginning of the process. By only running labeled bottles through, a smaller unit can be purchased and with smaller throughput, wear and maintenance costs are reduced, but with the expense of isolating the labeled bottles.

There is no standard case, but here is just one illustration to show unit sizing ballparks for one production scenario:

- 50 million lbs/yr plant (input), or 23,000 metric tons per year.
- Running at 80% “up-time”, and assuming a bale yield of 75%, daily output is 37,800 kg per day and 1,575 kg per hour of good bottles. For a 10% side stream of labeled bottles, the de-label machine will handle 157 kg per hour.
- For a 25% side stream of all labeled and colored bottles, the machine will handle 394 kg per hour.

Impact of this Equipment to PET Reclaimers

A detailed discussion of machinery purchase, installation and operating costs is outside the scope of this survey. But we do want to point out the following:

- These de-label machines have a capital cost to buy and require ancillary equipment such as conveyors to get bottles to and from the machine.
- The plant flow and lay-out for an existing plant may have to be re-worked to accommodate this unit.
- Sorting equipment and labor used for sorting is impacted. Additional machinery usually requires additional labor to monitor and maintain the equipment.
- The unit adds to the complexity of the recycling process creating extra operating and maintenance expense, down time, and opportunities for yield loss.
- Additional labor may be needed to hand sort bottles.

Survey findings

- Survey team identified 5 candidate suppliers with global supply capability. Three of the five responded to the survey.

- Machine capacity ranges from as low as 500 kg/hour up to 8,000 kg/hour. Suppliers report that the power requirements rise as the machine capacity increases. The range of power is from 11 kW for smaller units to 110 kW for the largest unit.

- Claimed sleeve label removal efficiency ranging from 80 to 96%.

- Machines can handle from 300 ml to 2,000 ml size bottles. Some adjustments might be needed to accommodate the "typical" bottle size. And baled bottles may handle differently from loose, not baled bottles.

- Loss of PET from "broken necks" reported to be less than 1% for all suppliers. Proper set-up conditions and handling practices minimizes the loss of broken neck when they do occur.

- In total, suppliers report over 100 de-label machines running around the world. But only a relatively few in North America.

- All use hardened steel wear parts. It takes several hours to change these parts when the level or wear requires a change be made.

- Quantity of material processed between wear parts change: 8,000 to 12,000 metric tons.

- Time to change wear parts: 5-10 hours.

- Machines can be configured either with side streams or to process all bottles in the bales. The configuration selection will be influenced by the needs of the plant and whether there is a retro-fit or new plant design involved. Another design consideration is whether the plant employs a whole bottle wash unit or not; a de-labeler will reduce the total label burden on a "dry" line and may provide benefits by removing labels from the flake wash tank.

- All suppliers report the availability of a pilot or demonstration unit for customer evaluations.

Conclusion

This survey finds that de-label machines are used around the world for managing the impact of PET bottles with shrink sleeve labels on the recycling process. Installation of a de-label machine may be the less costly alternative between adding cost to process sleeved bottles or sorting out sleeved bottles and eliminating them from the recycle stream (processing cost figures can be found in the "Industry Impact" report).

The delabeling equipment suppliers that members of the team have worked directly with are well aware of the need to:

- improve removal efficiency
- to decrease the amount of broken necks
- to reduce maintenance and operational costs

These variables are driven by differences in machine design and as a result can become an issue of competition between the suppliers. Even though these machines operate in similar modes, their efficiencies and resulting costs of capital are greatly influenced by the competitive marketplace.

2) Dry Grinding Shrink Label Separation Technologies

PET reclaimers who are using a dry grinding technology are less affected by shrink sleeve labels. One of the reasons is that they are not using any whole bottle pre-wash which modifies the form and shape of the shrink sleeve label. Therefore, some of those recyclers are able to partially remove those labels from the ground flakes using the technologies stated below.

Process	**Description / comment**	**Equipment supplier**	**Typical efficiency**
Elutriation	Air separation of light fractions using aspiration and gravity. Limiting factors include thickness of label vs. water bottle wall thickness, and loss of good PET flakes.	Amut (www.amut.it) B+B (www.bub-anlagenbau.de) Herbold (www.HerboldUSA.net) Kice (www.kice.com) Sorema (www.sorema.it) Sterling (www.sterlingblower.com)	5-20% with PET loss of 0.2%
Hydrocyclone	Hydrocyclone separation is based on material density but the process is also very sensitive to the flake surface to weight ratio. Typically, flakes are mixed with water to form slurry. This is then pumped to a cyclone where separation takes place. The general rule is that the floating material will exit through the top and the sinking material will exit through the bottom. The separation can also be affected by the unit configuration and type of material. In this case, the shrink sleeve film has a very high ratio and can be separated from thicker bottle flake when the proper hydrocyclone configuration is used. Also, some shrink sleeve flake curled in the hot wash process and air entrapment will make them float.	This is specific to each recycling plant and usually proprietary information	10-90% (when used with centrifugal dryers)

Flake Color Sorting	Some shrink sleeve flakes curl in the hot wash process. Because the ink is inside the curled film, most of the time, ink is not removed from those pieces. Therefore, some of those curled pieces are not identified and thus not separated when going through a flake color sorter.	NRT (www.bulkhandlingsystems.com) Pellenc (www.pellencst.com) Satake (www.satake-usa.com) Sortex (www.sortex.com) S+S (www.sesotec.com) Titech (www.titech.com) Unisensor (www.unisensor.de)	5-20%
Flake Electrostatic Sorting	Most of the shrink sleeve films are made either of PETG, PVC or PS. Those materials can be separated from PET using electrostatic flake sorters. Materials in an electrostatic sorter are agitated together in order to generate charges on each pieces of flake (positive or negative). Flakes are then fed onto a belt conveyor. At the end of the belt conveyor, the flakes are moving through the air close to a high voltage cylinder. The flake path is then modified based on the charges on each piece and collected in different chutes. Estimated budget cost for a 3000 kg/hr system could vary between $540K and $800K.	Hamos (www.hamos.com) Physep Components and Services, Inc. (ww.physep.com) (Carpco design)	75-95%

3) <u>Request for Solution Letter</u>

Even if we can now find label removal equipment on the market and also some equipment which is relatively effective at removing labels from ground flakes, we need to realize that this type of technology is in its infancy. Therefore, we have sent a letter to approximately 30 companies who are related to PET recycling. This letter (see below) is describing the issue and asking for support in providing technologies which would help APR members dealing with shrink sleeve labels.

The letter was sent to:

- STF Maschinen & Anlagenbau GmbH
- Physep Components and Services, Inc.
- Steinert US
- Eagle Vizion
- Commonsensesolutions, Inc

Copy of the letter sent in December 2014:

Subject: Request for Solution, Whole Bottle Shrink Sleeve Label Removal

Dear Mr./Ms.:

My name is Dr. John Standish and I am the Technical Director of The Association of Postconsumer Plastic Recyclers (APR). The APR represents companies who acquire, reprocess and sell the byproduct of more than 90% of the post-consumer plastic processing capacity in the United States, Canada, and Mexico.

The reason I am sending you this letter is to determine if your company has equipment or technologies that PET bottle reclaimers might be able to use to separate a whole bottle shrink sleeve label from the underlying PET bottle. The market for PET sleeve labeled bottles is growing rapidly and these types of bottles are presenting difficulties to the recyclers. They are struggling with how to identify that a PET bottle that is completely covered from the finish to the base with a fully decorated sleeve label is a clear PET bottle. Identifying the underlying material as PET is not a problem, but determining that it is an uncolored PET bottle is problematic. The color sortation equipment in use today will identify these fully decorated labeled bottles as "non-clear" and will reject them to the colored stream. This causes the recyclers to lose the value of these high quality clear PET bottles as they become part of the less-valuable colored bottle stream. Today, some reclaimers must manually remove these labels to add these bottles back into the clear stream. Unfortunately because of the manual labor required, this process unacceptably increases the reclaimer's cost to recover these bottles.

The reclaimers currently view technologies that can remove the labels from the bottles before they are sent through the color sortation equipment as the most efficient and ideal process available to date. While a number of recycling equipment manufacturers now make whole bottle label removal devices, these machines, while they can be effective, have not yet proven themselves to be the ultimate solution to this problem.

Thus we are seeking information on any technologies that your company might offer that would

- Efficiently remove these labels from bottles prior to the grinding process, and/or
- Separate shrink label film from PET flake after grinding.

We would be interested in your response to this inquiry to discuss what options you might offer for any equipment or technology that you believe might be efficient in this type of label removal.

I would be happy to discuss these requirements in greater detail or more fully explain the problems that the reclaimers are seeing. I look forward to your response and can be reached at 216-235-2724 or john@plasticsrecycling.org.

Following this letter, feedbacks were received from a few companies and could be summarized as follow:

- Boretech: Delabeler manufacturer from China (survey was sent to this manufacturer).
- Hamos: Electrostatic separation process (see dry process separation technology list).
- Flottweg: Manufacturer of sink-float equipment located in Germany. They think they might be able to separate the shrink sleeve label from PET flake.
- Eastman and Sun Chemical: Currently developing technology to have the label seam release in the whole bottle wash process.

Floatable Label Sub-Team

Sub-Team Members

R. Ben Shoshan	Polysack
W. Chiang	PepsiCo
M. Danner	Avery Dennison
K. Frydryk	Jindal Films (Sub-Team Coordinator)
R. Schantz	Klockner Pentaplast
J. Taylor	Printpack
C. Williams	Eastman Chemical

Executive Summary

The APR has identified shrink label films that float in the caustic bath, subsequent to bottle grinding, as one potential alternative to improve the separation of shrink labels from PET bottle flake. Main objectives of the sub-team were to research availability, applicability, impact, and potential use of materials that could address label floatability and separation.

The team focused on executing an industry survey, to identify the availability and performance of floatable film alternatives, according to established APR testing protocols.

Survey results indicate that floatable shrink label film options are available in the market, suitable for use in either machine direction (MD) shrink label, or transverse direction (TD) sleeve label format. The somewhat limited response to the survey request may be an indication of the early stage of development of these materials and subsequent use in PET bottle labeling applications.

Background

Shrink label materials are used as one key method of decorating PET bottles. Historically, the most commonly used materials for such labels include PETG, PVC, and OPS. Density of these materials (listed in the following table) is typically over 1.

	Polyolefin (PO)	Oriented Polystyrene (OPS)	PETG	PVC
Approximate Density	0.91 - 0.94	1.05	1.3	1.3

As the density of PET used to produce bottles is over 1, this normally does not allow for effective separation of PET bottle flake from label material, in the caustic bath following the bottle grinding step.

Alternate materials, including foamed polystyrene (PS), foamed polyester (PET), shrink films made from polyolefin (PO) materials, or applied coatings may result in label substrate density less than 1 and/or support separation of the label material by floatation in the caustic bath.

A common typical example would be the use of labels made from oriented polypropylene (OPP) film, used as labels for carbonated soft drinks. With a density below 1 (approximately 0.92), these labels have demonstrated separation from PET flake in the caustic bath, following bottle grinding.

Summary of Team Discussions & Key Identified Issues

Floatable sub-team meetings identified many issues related to the potential use of floatable label film materials in shrink sleeve labels. Selected key issues are summarized below.

1. Completion of an industry survey is needed to determine status of development and availability of floatable film alternatives.
2. The response rate for the industry survey was relatively low, with 40% of the requests returned with completed information.
3. Film density may change through the chain-of-use due to decoration or printing. As part of the conducted survey, respondents were asked to report available information on film density. Results are noted in the key conclusions.
4. Separated label material will likely become mixed with the polyolefin (PP, HDPE) cap stream. The potential impact of this was forwarded to the Industry Impact Sub-Team for further review.
5. The team discussed measures of success for the overall issue, defined to be negative impact on the quality of PET flake in the recycling process. Dialogue focused on the APR Bale Survey as a key lagging indicator of overall progress.
6. The potential use of a dissolvable label seam technology was introduced to the team and forwarded to the Label Removal Team for further assessment.
7. The overall adoption rate of the use of floatable shrink labels was identified as a potential issue.

Adoption Rate Observations

Development of Floatable shrink label materials is at a relatively early stage, compared to existing materials where the substrate technology is well established. In addition to meeting the recycling guidelines established by the APR, other factors may impact the rate of adoption of floatable shrink label film materials. Several key factors will likely affect Brand Owner decisions to proceed with floatable film materials.

1. Overall cost of use of these materials needs to meet brand owner requirements.
2. Fitness-for-use of the label material must meet operating and material standards required in the specific label applications. Key considerations include:
    a. Effective printing and ink adhesion in the printing process.

b. Effective forming of the label seam, acceptable seam appearance, and adequate seam strength to meet application requirements.
c. Consistent performance on the labeling machine, when applying label to bottle.
d. Adequate label shrinkage performance, to meet bottle design requirements.
e. Label material appearance. Lower haze of the label substrate may be required depending on the design of the label.
f. Additional label aesthetics, including surface gloss, resistance to scuffing and overall print quality.
g. Acceptable performance and label quality through the distribution cycle, including case packing, transport, warehouse storage, and associated tests (e.g. drop testing).

Industry Survey

The Floatable Label Sub-Team executed an industry survey, focused on identifying potential alternatives for supply of floatable film materials to the labeling industry. The process for conducting the survey and summarizing results is noted below.

1. Candidate companies for distribution of the survey were identified in a discussion between W. Chiang and John Standish (APR Technical Director). These identified companies included potential manufacturers of floatable film substrates, and potential converters (printers) of such label materials.
2. A survey document was developed *(see Attachment A)* by the Floatable Label Sub-Team, and forwarded to the identified companies by J. Standish, along with a request for completion.
3. Completed surveys were provided back to John Standish, who summarized the available data provided in the survey responses.
4. A final summary report of the available data was developed by the Floatable Sub-Team (*see Attachment B for the full report).*
5. Please note that the team contacted, for this survey, selected film manufacturers and label converters known to have floatable shrink labels. Additional floatable shrink label manufacturers may exist that were not included in the survey.

Industry Survey – Selected Results and Key Observations

A complete copy of survey results is included in *Attachment B.*

1. Survey Response
   a. A total of 15 companies were identified to receive the survey, with six responses.
   b. Available materials include films that support MD (machine direction) and TD (transverse direction) sleeve labeling
   c. One response was provided by a company providing a floatable film coating.

RESPONSE CHARACTERISTICS

NUMBER OF REPLIES		7
	Response Rate	50%
CONVERTERS		1
FILM PRODUCERS		4
INTEGRATED PRODUCERS & OTHER		2
TD SHRINK SOLUTIONS		8
MD SHRINK SOLUTIONS		4

2. Film Density
   a. Reported film density range for floatable shrink substrates is 0.91 to 0.96
   b. Through the chain of use, the film density increases to 0.95 – 0.98 due to decoration
   c. The expected increase in density through the chain of use may be estimated at approximately 0.025 to 0.03.
   d. As the density reaches 0.98 or higher, effective separation in the caustic bath may be a concern.
   e. Density of 0.95 or less, prior to converting, may be advisable to insure acceptable material separation. Actual efficacy would be determined by material testing according to APR test protocol standards.

FILM SUBSTRATE CHARACTERIZATION

FILM THICKNESS RANGE		40, 45, 50, & 65µ
DENSITY BEFORE CONVERTING	Range	0.91 - 0.96
	Mean	0.932
	#	10 replies
DENSITY AFTER CONVERTING	Range	0.95 - 0.98
	Mean	0.96
	#	7 replies
DENSITY POST RECYCLE	Range	0.95 - 0.98
	Mean	0.96
	#	3 replies
MAX SHRINK AMOUNT (on bottle)	TD (range)	50 - 78%
	MD (range)	15 - 60%

Industry Survey – Selected Results and Key Observations

3. APR Testing Results
    a. Six materials reported results based on testing according to the APR Shrink Label Test Protocol.
    b. Results vary somewhat widely, and are included in the full report.
    c. Some materials met existing test parameters, while some did not meet existing test standards.
    d. Impact of label material on PET plaque haze, and Δb* color are potential areas of sensitivity, depending on the specific label material.
    e. The pending change to PET plaque haze standards will likely allow more materials to meet the APR standard.
    f. Label materials will need to complete APR Critical Guidance testing to determine if the specific material meets APR guidance levels.

ATTACHMENT A

TD & MD Shrink Label **Floatable Label Material Survey Questions**

			Y/N		Y/N		Y/N
COMPANY NAME:		CONVERTER:		FILM MANUFACTURER:		INTEGRATED MANUFACTURER: (Film & Converting)	

1. Please provide product name(s) and corresponding data for your shrink sleeve materials that you believe would be considered floatable, and supportive of PET separation through the sink/float process.

	PRODUCT NAME	MD or TD SHRINKABLE?	THICKNESS (µ)	FILM DENSITY (before converting)	FILM DENSITY (post converting)	FILM DENSITY* (post recycle)	MAXIMUM SHRINKAGE ON BOTTLE
a.							
b.							
c.							
d.							

2. IF YOU ARE FILM MANUFACTURER, YES OR NO….has your company completed testing of you shrink sleeve label material, according to established APR guidance? ANSWER HERE____________________
3. IF you answered NO to the previous question, does your company intend to complete testing according to APR guidance? ANSWER HERE___________________
4. IF YOU ARE LABEL CONVERTER, YES OR NO….has your company completed testing of you shrink sleeve label material, according to established APR guidance? ANSWER HERE____________________
5. IF you answered NO to the previous question, does your company intend to complete testing according to APR guidance? ANSWER HERE___________________
6. IF YOU ARE INTEGRATED MANUFACTURER, YES OR NO….has your company completed testing of you shrink sleeve label material, according to established APR guidance? ANSWER HERE____________________
7. IF you answered NO to the previous question, does your company intend to complete testing according to APR guidance? ANSWER HERE___________________
8. If you answered YES to either question 2, question 4, or question 6, APR is interested to learn more about the results of your testing. Information you provide will not be used in any way to assess the functionality of your material, but instead will be used to characterize the overall performance of the range of materials that may be used as floatable shrink film solutions. The following data from testing, if available, would be of interest. Please attach more data if needed.

PRODUCT NAME →	a.)	b.)	c.)	d.)
TEST ITEM	RESULT	RESULT	RESULT	RESULT
PPM Residual Label Content				
Label Sink-Float *(Sink, Suspend, Float)*				
Clumping Test Result				
PET Plaque Haze				
L* Average – PET Plaque Color				
a* Average – PET Plaque Color				
b* Average – PET Plaque Color				

9. Please share or attach any other comments or relevant data and information:
10. The APR is also interested to get your input on what actions the APR could take to better enable your company to more quickly and effectively develop and commercialize new technology that might benefit the recycling industry:

Note:* Film Density-post recycle. If completed, this would be a measure of film density of label material separated following the sink-float operation.

ATTACHMENT B

Floatable Film Survey Response Results January 7, 2014

RESPONSE CHARACTERISTICS

NUMBER OF REPLIES	7
Response Rate	50%
CONVERTERS	1
FILM PRODUCERS	4
INTEGRATED PRODUCERS & OTHER	2
TD SHRINK SOLUTIONS	8
MD SHRINK SOLUTIONS	4

FILM SUBSTRATE CHARACTERIZATION

FILM THICKNESS RANGE		40, 45, 50, & 65µ
DENSITY BEFORE CONVERTING	Range	0.91 - 0.96
	Mean	0.932
	#	10 replies
DENSITY AFTER CONVERTING	Range	0.95 - 0.98
	Mean	0.96
	#	7 replies
DENSITY POST RECYCLE	Range	0.95 - 0.98
	Mean	0.96
	#	3 replies
MAX SHRINK AMOUNT (on bottle)	TD (range)	50 - 78%
	MD (range)	15 - 60%

APR TESTING INFORMATION

# OF COMPANIES WITH APR TEST RESULTS	5

APR test results are difficult to summarize as a group.
Individual replies on APR testing are copied into the table below.

ATTACHMENT B **Page 2**

Floatable Film Survey Response Results January 7, 2014

CATEGORY		FLOATABLE FLIM SURVEY RESPONSES 1	2	3	4	5	6	7	APR GUIDANCE[1,2]	REFERENCE MATERIALS[4] OPP WRAP LABEL	PET G SHRINK LABEL
Residual Label Content	ppm	**no data**	**NA**	**NA**	**112/<50**	**<50**	**354**	**no data**			
Sink / Float[3]		**no data**	**FLOAT**	**FLOAT**	**FLOAT**	**92%**	**FLOAT**	**88.03%**		96%	0%
Clumping Test Result	%	**0.01**	**0**	**0.06%**	***0***	**0**	**0.46**	**0.01**	**≤ 1% by Weight**	0.46	4.31
PET Plaque Haze	%	**13.4**	**22.87**	**10.96**	**9.54**	**9.54**	**22.87**	**14.85**	**< 20% haze**	7.92	9.23
Color values:											
L*		**86.4-87.07**	**84.62**	**87.84**	**88.21**	**>82**	**84.62**	**85.96**	**> 82**	87.76	87.75
a*		**-0.77 - - 0.35**	**-1.33**	**-0.081**	**-0.075**	**-0.75**	**-1.18**	**-0.7**	**Δa* < 1.5**		
b*[5]		**1.53**	**8.07**	**4.09**	**3.4**	**3.4**	**2.85**	**3.92**	**Δb* < 1.5**	0.89	1.3

1 Indicated APR Guidance is consistent with revised guidance recommended by APR Technical Committee and proposed to APR Board of Directors following October, 2013 APR meeting. Categories listed are not inclusive of all test categories required in APR Guidance, but reflect those properties viewed by Floatable Shrink Label Sub-Team to be most relevant in differentiating performance of substrates in APR testing.

2 Listed APR Guidance values generally represent test guidance limits for sample label material tested. Complete test protocol and requirements should be referenced through *APR Champions for Change*™ *Sleeve Labels for PET Bottles Critical Guidance Document*, which can be found on the APR website.

3 Sink / Float results were generalized by some respondents, indicating a float result. Other respondents provided results that are believed to indicate the amount of material removed before elutriation, and the amount removed after elutriation. The data in the table, where provided, indicates initial sink/float result before elutriation.

4 Residual Label Content and Δa* values unavailable on Reference Materials.

5 Reported b* color values were in some cases not clearly defined as absolute values or Δb values.

Ink Bleeding Sub-Team

Sub-Team Members

Weilong Chiang	PepsiCo
Jeff Sherwood	Flint group
Harold Osorio	Sun Chemical
Kristina Hansen	PFE
Helen Rallis	Sun Chemical
James Taylor	Printpack
Ronny Ben Shoshan	Polysack

Summary

APR recognized the impact of the growing use of the Shrink sleeve labels on PET bottle on the efficiency of the PET recyclers. While the industry is looking for different solutions to reduce the impact of sleeve labels on PET recycling, one identified need is that the ink adheres to the label, especially in the caustic wash solution process. Ink removed during the wash step can stain the PET flakes or come off as particles that do not separate from the PET flake.

The Ink Bleeding Team goal is to evaluate-the effect of ink bleeding from shrink labels on the recycle stream and evaluate approaches to prevent "ink bleed" into wash water. The results indicate that a commercially reliable solution is achievable and applicable. These potential solutions can be applied on the different printing methods available in the shrink label industry today, and adding small extra cost or no cost at all for the label printing. There are now APR recognized shrink films which display ink bleed resistance and meet the Critical Guidance test criteria.

Background

The Bleeding Ink Team members represent ink suppliers, label converters, film supplier, brand owners and laboratory service companies. Each individual played his role in providing his professional perspective and his facilities for sampling, testing and analyzing in order to promote solutions for the ink bleeding issue in shrink labels.

Objectives

- Evaluating the impact of the ink bleeding in shrink label on the PET flakes and the waste water in the recycle stream.
- Obtaining data on the current available solution/s, (if any) for this issue.
- Suggest potential and practical solutions to prevent the ink from staining the PET flakes

The challenges

1. Amount of ink

Sleeve shrink labels normally cover more area on the bottle vs. traditional non-shrink labels. In addition, traditional labels are easily removed in a whole bottle wash step before entering into the flake caustic wash solution. This is not the case for shrink sleeve labels, where no low bonding strength adhesive is being using, and the shrink sleeve label is maintained wrapped tightly to the bottle.

This is why, in shrink sleeve label the amount of label and therefore amount of ink entering into the caustic wash solution is several times more than in traditional non-shrink labels.

2. Single ply

Non-shrink labels are often a laminate of two layers of the film so the ink is trapped inside and it helps to prevent the ink from bleeding once it's entering to the caustic wash solution. On shrink sleeve labels it is a single ply and the ink is exposed directly to the aggressive environment of the caustic wash solution, which make it more challenging to prevent ink bleed.

3. Shrinkage property

Inks for shrink label require unique properties due to the process it goes through. It should be flexible enough when the label changes its dimension, resistant to high humidity and high temperature while exposing the label to the steam or hot air tunnel in the shrink label process. Therefore, it requires special ink properties and performance for shrink sleeve labels.

4. Different pigments tend to stain at different rate

The acceptable threshold for staining by pigment type and ink system has not been established.

Team discussion and key identified issues

- The amount of ink entering to the caustic wash solution is a given for the ink bleeding team. The challenge to reduce this amount before it reaches to the grinding and washing is being investigated by the Label removal sub-team.
- Due to the fact that common shrink label materials are PVC, PET-G and OPS where each of these has a density greater than the density of water ($1gr/cm^3$), so each of these shrink label materials will sink in the sink/float process with the ink, and will stain and contaminate the PET flakes (see floatable label sub-team report), therefore, the investigation of ink bleeding for shrink labels is relatively new area.
- Lamination – This can be one optional solution that has been discussed to minimize the ink bleeding. However, this type of solution involves a long development process, has the shrink sleeve label today is a single ply. In addition, this lamination solution will had extra cost for the label. The team agreed to focus in preventing the ink releasing from the label in this work.

- Ink types - How do inks like silver color (aluminum powder) and other metallic ink influence the ink bleeding and contamination of the PET flakes.
- Ink level - One of the key questions raise in team was what is the level or amount of ink which allows bleeding and still will not stain the PET Flakes.
- Discoloration - There are two types of discoloration: discoloration from dirt and discoloration from ink pigment and binder. The discoloration of the water due to ink bleeding is also undesirable by the recyclers and there is no established acceptable level today.
- Label substrate - The team discussed and investigated. It was part of the industry survey (see below) if ink bleeding will be different when using a different substrate material.

<u>Team activities</u>

- Different ink families of different printing methods, such as solvent, UV, and water base, were tested on different substrate (such as PVC, PET-G, PS and PO) shrink material, both MD (machine direction) and TD (transverse direction film).
- At first, the inks were applied hand proofs and if results were positive, printing on press was done.
- The samples were tested at first internally according to the APR protocol.
- Industry survey sent to ink suppliers to obtain data of the different solutions available today for the ink bleeding issue. (The survey is below under the section "industry survey".)
- The team seeks to understand any regulations regarding the discoloration from ink of recyclers' water waste. First data present below

<u>Results and conclusions</u>

- MD vs. TD film seems to have no difference in terms of ink bleeding. However, the substrate material might affect the results as different substrates required different ink systems, and one may be better than another in terms of adhesion of the ink to the surface.
- Solvent, UV and Electron Beam inks base are more favorable. While printing methods (such as Roto-Gravure, Flexo) seems to have no impact on the results.
- Primer and/or OPV have been proven to assist in prevent the ink bleeding, but not in all cases.
- Solutions with no OPV and/or primer were investigated, and showed some promising results.
- Different pigments tend to stain at different level. The binder chemistry is the critical variable.
- No metal inks were tested on this work.
- Discoloration of wash water and regulations - Here is some of the first information coming from 3 recyclers:
    - From regulation stand point there are some factors that they measure:
        - BOD (Bio Oxygen Demand)
        - COD (Chemical Oxygen Demand)
        - TSS (Total Suspended Solid) is the major factor.
        - Measuring the metal that there is in the water
        - pH
    - First conclusion is that different states have different regulations on the value required and the effect of the pigments has not been investigated yet.

Ink Bleeding Test Survey - Film Substrate Characterization

This survey has been sent to 5 large ink suppliers for the shrink industry while 3 of them replied. In order to keep confidential data and for sake of simplicity the answers below are a summary of their responses.

In your experience does the label type (MD - Machine Direction and TD - Transverse Direction film) have a contribution to the ink systems ability to bleed more?

The film direction has not been evaluated as a contributor to the ink bleed at this time. MD seems to be the common film orientation.

Has film thickness been a factor with your evaluation on ink bleed or staining?

The thickness has not been a specific variable of change when evaluating the films. Typical thickness range is 35-50 microns.

Has substrate material type been a factor with your evaluation on ink bleed or staining?

Different film types have been evaluated. The ink to film adhesion can increase or decrease from one film type to another.

Has shrink rate of a substrate material type been a factor with your evaluation on ink bleed or staining?

The shrink rate could increase the probability of inks flaking if the film substrate shrinks beyond the inks shrink capabilities. Also, materials such as metallic based inks can have increased flakes.

Ink Bleeding Test Survey – Print Processing

Has Solvent, water based, or UV/EB or others been observed as more recycle friendly than another when evaluation on ink bleed or staining?

Energy curable inks UV/EB and solvent based are viewed as more favorable for shrink.

Has Roto-Gravure, Flexo, or other methods of printing been observed as more recycle friendly than another when evaluation on ink bleed or staining?

The printing method (flexo or gravure) does not appear to change the bleeding/staining of the inks. It is more so, the chemistry of the ink systems. Not all ink systems can be used on both Flexo and Gravure printing methods.

Has Primer or OPV been more successful to not stain or bleed in the recycle washing process?

Yes, a primer and OPV have been proven to assist in the inks not bleeding, but not necessarily solve the issue in all cases.

With testing completed to this point, were inks applied by a press or by hand?

Hand proofs and press printed labels have been evaluated. There is variation between the two methods.

In the range of colors offered has it been seen that some pigments have been more challenging to design not to bleed?

Yes, different colors have bleeding and staining challenges and complications. The resin carrier/binder chemistry is a critical variable.

Do you have an ink system that has been tested and confirmed recycle friendly and commercialized?

Shrink label ink systems are a continuous improvement process. There have been some systems seen as favorable but no recognition has been presented to formally at this time.

If so, are you willing to share any data/results completed at this time internally or externally?

Internal and external testing has been completed but the results are not currently available for the public at this time.

Test Methods Sub-Team

Sub-Team Members

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Objectives and Goals

The objective of the Test Methods Team was to review and update the Sleeve Label Ink and Substrate for PET Bottles Critical Guidance Document. This document was developed to help innovators evaluate the impact their shrink sleeve labels might have on the recyclability of PET bottles. This test protocol was re-examined to ensure it was properly designed using suitable guidelines so that it accurately gauged the recyclability of a shrink label on a PET bottle. Additionally, because there was significant overlap between numerous APR label and ink test procedures, it was necessary to review all existing tests to identify inconsistencies between the test protocols. Then using the latest test methods and guidelines developed for the Shrink Sleeve Label and recently approved Pressure Sensitive Label tests, identify the changes that would need to be made to these other tests to ensure consistency in test protocols and guidance values. An additional goal was to develop bench tests that would assist and guide a sleeve manufacturer and/or brand owner in understanding how their particular label would be treated in the auto-sortation process. This goal was felt to require a significant amount of time and effort that went beyond the ability of the Team to handle. Thus the Team elected not to focus on that aspect of shrink labeled bottles at this time.

Shrink Sleeve Test Protocol Background

The Technical Committee of the APR began working on a test protocol for shrink labels as early as 2010 as the recyclers were beginning to find these bottles in their bales at ever increasing levels. The problems included higher losses due to the auto-sortation machines rejecting them as both non-PET and colored PET bottles as well as increased discoloration due to inked labels being carried along with the clear PET and increased haze from entrapped non-PET label substrates. The current Sleeve Label on PET Critical Guidance Document (CGD) was based on the existing PET Bottle CGD with modifications designed to specifically address shrink labels and was subsequently approved by the APR Board in late 2012. As this test protocol was being used, it became apparent that it no longer properly addressed some of the issues being faced. Thus the Team began re-examining some of the premises on which the original test protocol was designed to ensure that these were still valid and if not, suggest changes that needed to be made to better reflect how to evaluate the impact on the PET recycle stream for developmental shrink label materials and labeled bottles intended for introduction to the market.

Test Methods Team Findings and Recommendations

After numerous discussions and review of current available shrink label data, the Team identified the following areas that needed to be addressed in the test protocol:

- The use of an "Intended" bottle was too restrictive for all studies; a generic label/bottle option needed to be added.
- While an "Intended" label should be evaluated fully printed/decorated, any generic label substrate should be studied unprinted/undecorated.
- The "Protocol for Producing PET Flake and Evaluating for Discoloration from Bleeding Labels" needed to be removed from the test protocol and simply be referenced as a supporting test.
- The wrap-around polypropylene control was not needed as a second control.
- Guidance value changes were needed to reflect current findings
    - a* should be reported and included with the color measurements with a guidance value set to <1.5 unit increase over the control.
        - Use of CIELAB methodology rather than CMC would be continued at this time.
    - Haze guidance value for the control would remain the same, but would increase from <9.5% to <20% for the test samples.
- Based upon these suggested changes, several other current APR test protocols would now need to be revised to ensure consistency.

Each of the suggested changes noted above were arrived at to create a more streamlined, efficient, and appropriate test protocol that would offer an improved process of evaluating shrink sleeve labels for their impact on the PET recycle stream. Further explanations on each of these suggested changes follows.

Intended vs. Generic Bottles

Brand owners may be in an excellent position to evaluate their specific bottle with an applied printed shrink sleeve label to determine its recycling performance. However, label substrate manufacturers, ink suppliers, and label producers frequently do not have access to many of these proprietary bottle designs to use in their development programs. Therefore, the ability to use a generic designed bottle to which they can apply their label for evaluation offers them the ability to more easily perform their development studies before engaging with their respective customers.

In order to determine what the label weight-% should be for a generic evaluation, an analysis of shrink-wrap labeled bottles taken from the market showed that the average label weight was ~7% of the bottle weight. However, the median weight-% was closer to 6% as the average was skewed to the high side by a small number of samples, thus a minimum 6% of the bottle weight shrink label target weight was determined to be reasonable for generic label/bottle studies. Because the APR CGD test protocols evaluate innovations at a maximum study level of 50%, it was decided that if the label weight was set to 3% for a generic study, then this variable would not need to be diluted 50% with control flake. This change allows a study to be done using less material.

Bleeding Label Test

The current Shrink Label test protocol included the Bleeding Label test protocol as an appendix document. Inclusion of this entire test protocol was felt to be unnecessary and thus the Test Methods Team recommendation was to remove it and reference this test within the appropriate section of the shrink sleeve test protocol.

Polypropylene (PP) Wrap-around Control

Because minimally adhered wrap-around PP labels are prevalent on many bottles currently found in the recycle stream, it was felt that including them as a label control would assist in understanding how much haze might be seen in a study that was being caused by any remaining residual shrink label that also had a density <1 when compared to the common wrap-around label. The value of this added control was determined to be negligible while it added additional cost to the test, therefore, the recommendation is to remove it from the test.

Guidance Changes

<u>Color Measurement Method</u>
Current color measurements are made and reported for APR tests using CIELAB methodology where L*a*b* is used to reflect the color of a measured article. This method of measuring color defines a three-dimensional rectangular coordinate system where the color is located within that space. L* indicates how light or dark the color is, a* is the position on the red-green axis and b* defines the position on the yellow-blue axis. CMC, color defined by an ellipsoid space, is a modification of the CIELAB method and this method is believed to better correlate with what the human eye sees. A suggestion was made to begin using this newer methodology to report color, but the Team felt that making such a change here would be too complicated and would produce significant deviation from historical data thus complicating current color guidelines. Subsequently, the decision was made to not make this change at this time; however, it is a subject that should be addressed by the Technical Committee for review.

<u>a*</u>
a* has typically been included with all color measurements made on all samples regardless of the test. However, there was no acceptable guidance level set for many of these tests. Because the shrink label test will evaluate printed labels on Intended bottles, the recommendation is to now include a guidance value for a*. Based on the analysis of data obtained from studies on printed labels, a guidance value of <1.5 increase over the control is being suggested for incorporation into the test protocol.

<u>Haze</u>
Studies performed on a variety of resins in the market about eight years ago helped to establish the 9.5% guideline for acceptable haze levels that is now part of all test protocol guidelines. The resins in the market today have changed and thus a re-evaluation of what defines an acceptable haze level was felt to be necessary. Many studies that have been run that show 3mm control resin haze levels being 6-7% where some have even exceeded the 9.5% guideline. Bottles taken from the market were measured to determine their % haze. These values were then normalized to a wall thickness of 0.010". The average haze value of these bottles was found to be ~2%. Additional studies have shown that a 3mm plaque with a haze of 15%, when blown into a bottle would produce a bottle sidewall haze level of ~1.5% while a 3mm plaque with 20% haze would equate to a bottle sidewall haze of ~1.7%. Thus it

appears that the current guidelines that do not allow any increase over the 9.5% haze level are much too restrictive. Therefore, the recommendation is to allow the Innovation 3mm plaque haze to not exceed 20%.

Agreement Between all Related APR Test Protocols

The Team reviewed other related test protocols to identify where there were, or will be, discrepancies between test protocols if the above suggested changes are approved by both the Technical Committee and the APR Board. A check mark (√) in any cell in the Table below indicates that there may need to be a change made to the current protocol in order to be consistent between all tests.

Test*	Study Level	Addition of a* Guidance	Increased Haze Guidance
PET CGD		√	√
PET CGD/Appl.		√	√
Plastic Label/Closure Fast Test (with Plaque molding))			
Wrap-around	√	√	√
Shrink Sleeve	√	√	√
Pressure Sensitive	√	√	√
PET Quick Test		√	
Pressure Sensitive Labels			√
Bleeding Label (for Flake only)			
Wrap-around	√	√	
Shrink Sleeve	√	√	
Pressure Sensitive	√	√	
PET Thermoforms		√	
Degradable Additives Test		√	

*Test protocol names as found on the APR website are:
PET Bottle Critical Guidance Document
PET Bottles Applications Guidance Document
Plastic Label and Closure Fast Test for PET Bottles
PET Quick Test for Color
Pressure Sensitive Adhesive Label for PET Bottles Critical Guidance Document
Protocol for Producing PET Flake for Evaluating for Discoloration from "Bleeding Labels"
Protocol for Evaluating PET Thermoform Labels and Adhesives for Compatibility with PET Recycling
Degradable Additives and PET Recycling Technical Compatibility Testing Guidance

Each of these test protocols will need to be reviewed and rewritten to insure that not only are the guidelines being changed, but to insure that the required study levels and weight-% of the Innovation articles are also adjusted as necessary. These screening tests are designed to give Innovators and Brand Owners an accurate quick recycle impact analysis to guide their developments while still being stringent enough to yield confidence that if the new development passes the screening tests, then it will also have a very good chance of meeting all the guidance values in the more rigorous Critical Guidance Tests.

The End