ASSOCIATION OF PLASTIC RECYCLERS

SORTING POTENTIAL TEST METHOD:

Evaluation of the Color Sorting Potential of a Clear PET Article with Label Coverage Greater than APR Design Guidance[1]

[1] *Articles with label coverage greater than or equal to the following limits require testing: Container volume 550ml or less: 55%. Container volume > 550ml: 70%. Label coverage is defined by the label surface area divided by the article surface area.*

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Introduction

Scope, Significance, and Use

This test is one in the series of "Sorting Potential Test Methods" developed by the Association of Plastics Recyclers (APR).

The sorting potential test methods describe laboratory-scale representations of the most commonly used collection and Material Recovery Facility (MRF) processes for handling single-stream postconsumer recyclables. The test methods assume that these co-mingled recyclables are collected curbside, compacted in a typical recycling collection truck, transported to and processed through an automated MRF into bales of similar plastics, then further processed at the plastics reclaimer in their original form before being reduced in size.

These tests do not consider the plastics recycling process starting from or after size reduction at the plastics reclaimer. Nor do they represent other processes that may use different methods of collection and separation with different results. Furthermore, plastic sorting processes have some degree of variability in commercial practice. It is not the intent of this protocol to model every possible process outcome, but to choose a common set of parameters, widely employed, and which fall squarely within those used by industry.

The sorting potential tests are intended to identify specific design features that may cause an entire package to be lost in the recycling process. The consequences of a plastic article being mis-sorted prior to size reduction are more significant than in processes that follow size reduction since the entire package is lost to the plastics recycling stream rather than a mere component of the package. The modeling of sorting behavior in this test enables design engineers to focus their improvement efforts and is designed to complement the wide range of tests offered by APR that form the foundation of APR's Design Guidance for plastic package recyclability.

Note: Many people recognize the optical bottle sorting process within MRFs, however, US MRFs don't typically sort PET bottles by color. The color sorting process occurs at the PET recycler.

Typically, today's PET reclaimers employ automated equipment that sorts plastic packaging and other items by color into three distinct groups: Clear + transparent light blue, transparent green, and other colors. For this equipment to operate effectively, it must accurately identify the color of the PET container beneath the label and direct it to the correct location. Otherwise, the article may be downgraded to a less valuable color stream. Large coverage labels can cause the article to be misdirected.

This specific Color Sorting Potential Test Method provides a means of evaluating whether a clear PET package that employs a label with a high surface area coverage can be accurately identified and sorted on pilot scale color sortation equipment that performs similarly to that used in production facilities. Good results in this benchmark test indicate

that a plastic article has the potential to be sorted well in production conditions. Poor results indicate that an improvement in package or label design is desirable to promote recovery.

The test involves establishing the baseline performance of a commercial color auto-sorter that is located within a lab setting—adjusted as it would be at a PET recycler—by processing a known blend of material while targeting the color of the test article. Then, 20 samples of the test article are added and the mix is reprocessed. Sorting efficiency of the test articles is compared to the baseline efficiency. Five passes through the color unit are used to develop repeat values for the test articles.

The test involves establishing the baseline performance of a pilot NIR sorting machine by processing a known blend of material while targeting the polymer of the test article. Then, 20 samples of the test article are added and the mix is reprocessed. Sorting efficiency of the test articles is compared to the baseline efficiency. Five passes through the NIR unit are used to develop repeat values for the test articles

Note: Test results from one laboratory are sufficient since the evaluation is measured against that machine's own baseline.

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Reference Documents

- Compression Practice : SORT-P-00 Practice for Compressing Plastic Articles for Laboratory Evaluation
- APR Recommended Testing Facilities: https://plasticsrecycling.org/apr-design-hub/testing-protocols-labs/apr-recommended-testing-facilities/

Test/Method Summary and Flow Diagram

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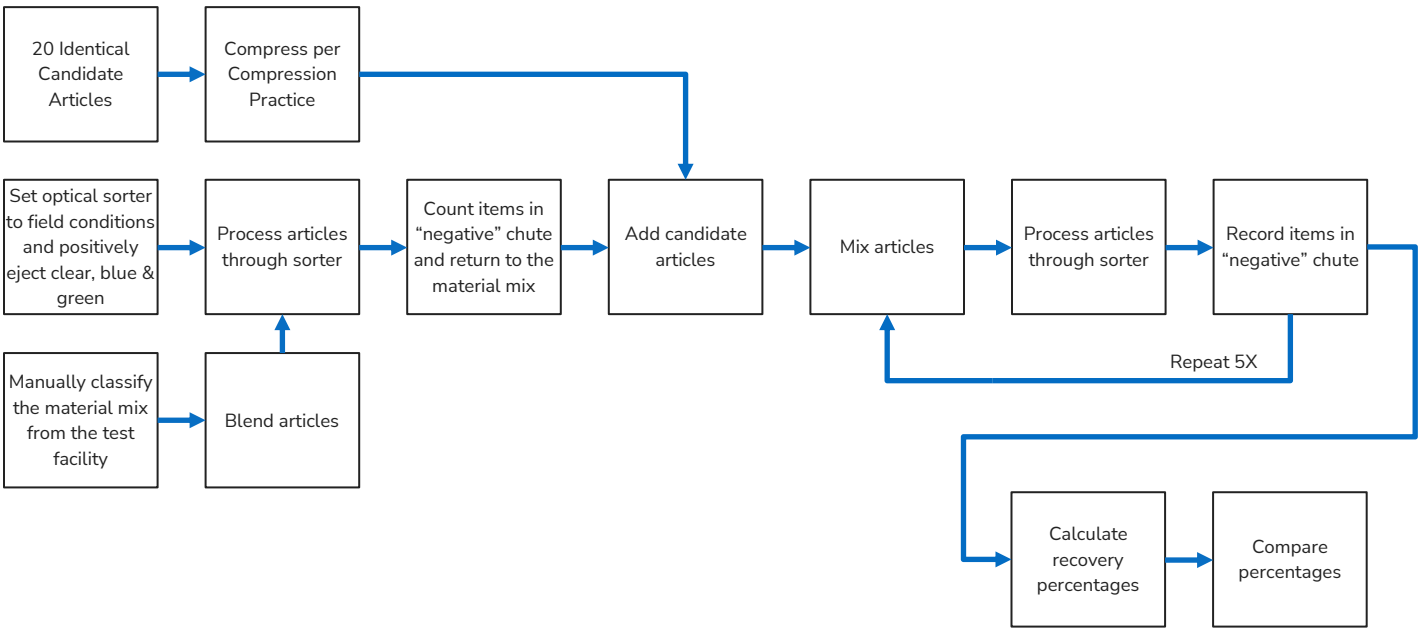
The flow diagram below outlines the test process. First, the baseline sorting efficiency for the polymer in question is established by running a mix of known items through the color sorter and recording the sortation results. Then, 20 of the candidate articles are added to the mix and it is processed through the color sorter. This is repeated five times. The results of the baseline sorting efficiency and the candidate article sorting efficiency are then compared.

Note: The terms “test article” and “candidate article” are used synonymously throughout this document.



Equipment Required

1. Bottle compression device built per the instructions found at SORT-P-00 Practice for Compressing Plastic Articles for Laboratory Evaluation
2. Binary Color bottle sorter operating in representative (reflective or transmissive) mode of typical field equipment, with applicable feed belt and discharge chutes. This test is conducted on pilot plant scale color sortation equipment. Please refer to "APR Recommended Testing Facilities" found at https://plasticsrecycling.org/apr-design-hub/testing-protocols-labs/apr-recommended-testing-facilities/ for a list of potential test locations.

Note that operating PET reclaimers are not normally prepared or experienced in this method, so a controlled laboratory environment is required. These businesses each maintain and operate pilot scale sorting equipment. There may be a service fee for pilot evaluations.

Materials Required

1. Twenty (20) identical candidate test articles provided by the test applicant. These articles should be fully decorated, i.e. with label, closures, etc. as they would be if placed in a curbside bin after consumer use. Note that these articles are empty whereas some residual product may remain in the articles found in the actual recycling stream. Sorting machines are generally programmed to minimize the effects of common amounts of residual product so this test does not consider residual product.
2. Mix of PET articles representing the proportions commonly processed through a PET recycling line. This mix should be of sufficient quantity to operate the trial sorting machine at 50% nameplate throughput or greater for at least one minute (a general rule of thumb for nameplate capacity is one ton per hour per meter of machine width, which equates to 34 pounds per minute, or approximately 733 bottles per minute, but this ratio is dependent on manufacturer). These articles are normally provided and maintained by the test lab, should be previously compressed through the actual collection system, and include labels and attachments. By weight percent the mix should consist of:
   - 83-86% by weight, clear and transparent light blue PET containers between 8 oz. and 2 liters, ensuring that at least 20 of each of the following are represented:
     - clear single serve water
     - transparent light blue single serve Dasani or similar color (Note: Dasani is chosen since it is generally regarded as the darkest blue accepted at a recycler)
     - clear 2-liter carbonated soft drink
   - 10-13% by weight transparent green PET containers between 8 oz and 2 liters such as Mountain Dew.
   - 2-4% by weight colored PET containers between 8 oz and 2 liters, ensuring that at least 10 of each of the following colors are represented:
     - Amber
     - Opaque white
     - Dark Blue

Method Steps

1. Take pictures of all articles for submission including:
    a. One candidate test article before compression
    b. All candidate test articles after compression (one collective picture)
    c. The mix of other articles (one collective picture)

2. Compress the candidate articles according to the APR compression practice found at SORT-P-00 Practice for Compressing Plastic Articles for Laboratory Evaluation

    Alternatively, a horizontal or vertical ram baler may be used since color sorting in the recycling process is accomplished after the bottles have been baled.

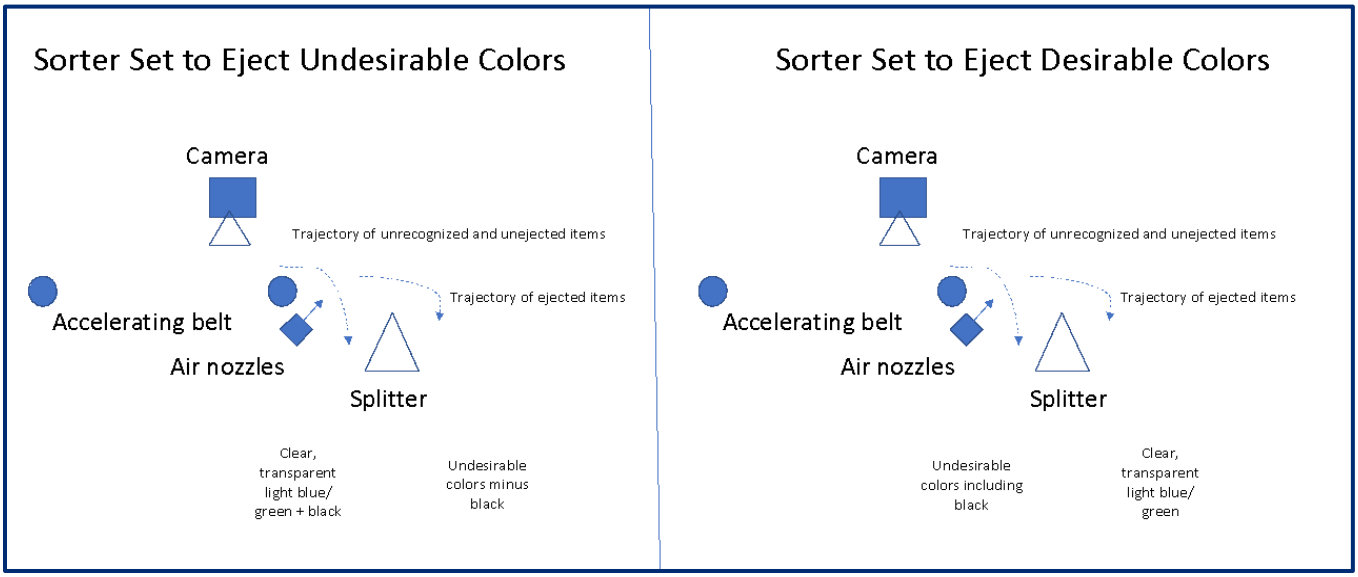
    Note: This is an extremely important step since compression helps flatten the articles,

    making them less likely to slide on the conveyor belt. Successful optical sorting requires articles to remain stable on the conveyor belt so the ejector can be timed with the sensor. Sorting tests performed on rounded items that are not compressed may have poor results.

3. Collect and classify the material mix (it is anticipated that the testing lab maintains this mix in its facility for use as required and the classification has already been completed):
    a. Complete the attached form in Annex #1, classifying the mix with the weight and count of each article type.
    b. Ensure the mix is of sufficient size to feed the sorter at 50% rated throughput, or greater, for at least one minute. It is permissible and expected to adjust the usable width of the sorter to fall within these parameters.
4. Establish the baseline:
    a. Using the manufacturer's operating procedure and color only, set the sorter to positively sort a typical clear stream plus the typical green stream within a PET reclaimer into the same stream. DO NOT USE THE TEST ARTICLE TO ADJUST THE SETTINGS.

        Note: The purpose of this test is to represent the performance of the machines in the field, not the capabilities of the latest machine version. Therefore, this test is not an appropriate brand-to-brand or machine-to-machine comparison.
    b. Blend the material mix without the candidate articles in a container so they are randomly mixed.
    c. Meter the mixed articles onto the accelerating belt (or vibratory feeder – depending on test facility) at a rate at least 50% of the sorters nameplate throughput.
    d. The mixture is carried by conveyor belt through the sortation equipment and sorted.
    e. Record the number and percent of the target polymer articles incorrectly sorted on the form below.

WHY DOES THIS TEST POSITIVELY EJECT THE DESIRABLE COLORS?... BLACK



In the test described above, the desirable colors are ejected, as diagramed at right above. If the color sorter ejected the undesirable colors, as on left—the common color sort practice—black items would always pass this test. The desirable colors in the context of this test are containers that sort as clear or transparent light blue / green.

5. Test the candidate article:
   a. Combine both sorted streams to recreate the material mix.
   b. Randomly place the candidate articles into the material mix. This can either be done by mixing them all in a bin or by placing the candidate articles one at a time onto the accelerating belt while the material mix is being processed.
   c. Meter the mixed articles onto the accelerating belt (or vibratory feeder – depending on test facility) at a rate at least 50% of the sorters nameplate throughput.
   d. Record the number of candidate articles positively sorted on the form below.
   e. Repeat 5 times. Note, if a label dislodges from a candidate article at any time, replace that candidate article in the next repetition.

Measurements

For each run, record the count of the test articles in the un-ejected stream per the report form.

Report Form

Found in Annex 1

Assessment

Variance = The difference between the sorting efficiency of the test polymer established in the baseline test, minus the sorting efficiency of the test article in aggregate of the following tests (see calculations in the report form and example).

Capture rate = The average percentage of test articles correctly sorted in the aggregate of the tests (see calculations in the report form and example).

If Variance is < =5%: The candidate article is most likely to be sorted correctly by the color sorter and the APR Design Guidance category for the design feature of "optical sorting potential" is **APR Design® Preferred**.

If Variance is >5%: A higher than optimal percentage of the test articles will be missorted by the color sorter. The APR Design Guidance category for the design feature "color sorting potential" is **Detrimental to Recycling**.

Annexes

1. **Report form: Evaluation of the Color Sorting Potential of a Clear PET Article with Label Coverage Greater than APR Design Guide Limits**
2. **Sample completed report form and calculations**

Table and Figures

None

Annex 1: Report Form

NEAR INFRARED SORTING POTENTIAL OF A WHOLE PLASTIC ARTICLE
Record Sheet – APR Test

Background

Testing Facility		
Testing Facility Technician		
Date		
Candidate Article Description	*Volume*	
	Color	Clear
	Label Material	
	Closure Material	
	Body Material	PET
	Brand/Description	

Machinery

Nameplate Throughput for the Width Used (lbs/hr)	
Weight of Material Required for 50% Rated Throughput for 1 Minute (lbs)	

Material Mix

Material	Target % by weight	Actual weight	Count
Clear & Transparent light blue PET containers	83-86%		
Transparent green PET containers	10-13%		
Colored PET containers	2-4%		
	Total		
			% of material required for 1 min. run

Baseline Test

# of clear, transparent light blue, and transparent green articles incorrectly sorted (in the negative sort bin)	
% of clear, transparent light blue, and transparent green articles incorrectly sorted	
Baseline capture rate (100% – & incorrectly sorted)	

Candidate Article Tests

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
# of test articles incorrect						
% of test articles incorrect						
Test capture rate (100% – total % incorrectly sorted)						

Variance Calculation

Baseline capture rate – Test capture rate Variance _____

Assessment

Variance	Applicable APR Recyclability Category for "NIR Sorting Potential" (see category descriptions in APR Design® Guide for Plastics Recyclability Homepage	Check Applicable Box
< = 5%	APR Design® Preferred	
> 5%	Detrimental to Recycling	

Testing Facility Technician Signature _____

Comments

What features cause negative results?, What could be done to improve sorting?, etc.

These results are not to be misinterpreted or misused to judge the performance of individual macine manufacturers.

Annex 2: Sample Completed Form and Calculations

Evaluation of the Color Sorting Potential of a Clear PET Article with Label Coverage Greater than APR Design Guide Limits
Record Sheet - APR Test #

BACKGROUND		
TESTING FACILITY		DOES SORTING
TESTING FACILITY TECHNICIAN		JANE DOE
DATE		SEP 24, 2020
CANDIDATE ARTICLE DESCRIPTION	Volume	600 ML
	Color	Clear
	Label Material	PP
	Closure material	PP
	Body material	PET
	Brand/Description	ACME JUICE

MACHINERY	
NAMEPLATE THROUGHPUT FOR THE WIDTH USED -lbs/hr	2000
WEIGHT OF MATERIAL REQUIRED FOR 50% RATED THROUGHPUT FOR 1 MINUTE: - lbs (2000/60/2)	17

MATERIAL MIX

Material	Target % by weight	Actual weight	Count
Clear & Transparent lgt blue PET containers	83-86%	25.5	459
Transparent green PET containers	10-13%	3.3	59
Colored PET containers	2-4%	1.2	30
	Total	30	
30/17		176%	% Of material required for 1 minute run

BASELINE TEST

# of clear, transparent light blue and transparent green articles in the negative sort bin (incorrectly sorted)	20
% of clear, transparent light blue and transparent green articles incorrectly sorted	$\left(\frac{20}{(459+59)}\right) \times 100 =$ 3.9%
Baseline capture rate: (100% - % incorrectly sorted)	$100 - 3.9 =$ 96.1

CANDIDATE ARTICLE TESTS

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	TOTAL
# of test articles incorrect	1	2	1	2	0	6
% of test articles incorrect	5%	10%	5%	10%	0%	

Test capture rate (100% - total % incorrectly sorted) $100 - 6 =$ 94%

VARIANCE CALCULATION

Baseline capture rate - Test Capture rate

$96.1 - 94 =$ variance 2.1%

ASSESSMENT

Variance		*Applicable APR Recyclability Category for "NIR Sorting Potential" (see category definitions In APR Design Guide for Plastics Recyclability Home Page)*	*Check Applicable Box*
< = 5%	2.1	APR Design Guide Preferred	✓
> 5%		Detrimental to Recycling	

Testing Facility Technician Signature [signature]

Comments: What features cause negative results?, What could be done to improve sorting? etc.

These results are not to be misinterpreted or misused to judge the performance of individual machine manufacturers.

Disclaimer

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Document Version History

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1	December 11, 2017	Original
2	May 15, 2018	
3	August 30, 2024	Change to Naming Convention (B) to (S) to match Single Purpose Test and Naming of Compression Practice; Changed hyperlinks to match new website