ASSOCIATION OF PLASTIC RECYCLERS

SORTING POTENTIAL TEST METHOD:

Evaluation of the Two Dimensional/Three Dimensional (2d3d) Sorting Potential of a Whole Article

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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 typical, set of parameters widely employed by industry, thereby creating an expected average result for the most common processes.

Introduction

Scope, Significance, and Use

This test is one in the series of voluntary "Sorting Potential Test Methods" developed by the Association of Plastics Recyclers (APR). The sorting potential test methods describe laboratory-scale representation of typical collection and Material Recovery Facility (MRF) processes for handling single-stream post-consumer recyclables. Preparation of the test sample is designed to simulate how 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 materials, then further processed at the plastics reclaimer in their original form before being reduced in size.

These do not consider sorting steps in the plastics recycling process after size reduction at the plastics reclaimer.

2d3d Sortation

The APR sorting potential test methods are intended to identify specific design features that may cause an entire package to be lost in the recycling process, with the 2d3d sorting potential of the package being one such design feature. Most APR sorting potential test methods result in the design feature being classified as one of the APR recyclability categories; Preferred, Detrimental to recycling, or Non-recyclable. However, since nearly all plant processes employ quality control steps on each outtake of the 2d3d sortation to address missorted articles 2d3d sorting is not definitive. Many newer plants use optical sorters on each outtake of the 2d3d separation to redirect the 2d3d missorted materials into the correct stream. Therefore, it is not possible to classify an article that does not sort well in 2d3d as "not recyclable" since it may be sent to the correct stream in a QC step. Articles incorrectly sorted by 2d3d have undue processing and quality impacts so they are classified "detrimental" per APR's definition of "detrimental to recycling". The modeling of 2d3d sorting behavior in this test method enables packaging 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.

The feedstock for a single stream MRF contains paper and glass which must be removed and aggregated into separate streams prior to introducing the remaining material into the "container line". Cardboard, newsprint, and glass are removed first through size sortation. The 2d3d separation step is employed after size sortation and prior to the container line to separate remaining paper from containers. 2d3d separation machines are sloped so light, two dimensional articles travel up and over the machine and heavier three-dimensional articles fall down and backward on the machine.

This Protocol

This specific test method provides a means of evaluating whether an article can be accurately sorted on commercial scale 2d3d sortation line in a controlled environment. The equipment in this test method has been adjusted and verified to represent the "average" commercial 2d3d separation machinery in practice today whether that be a star screen or ballistic separator. Good results in this screening test indicate that an article has the potential to be sorted well in production conditions. Poor results indicate that an improvement in product design is desirable to promote recovery.

The test involves compressing 50 identical test articles to simulate the hauling process and mixing them into a stream of material that represents the material that might normally be encountered at this stage of the sorting process. In addition, 50 samples of a control package are added and marked. The entire batch is run through the test machine at the designated operating parameters. The number of articles incorrectly sorted for both the control and the candidate article are counted so a sorting efficiency can be calculated. This test is performed three times. The resulting sorting efficiency is then compared between the test articles and the control.

Reference Documents

- Determining Packaging Dimensions that Require 2d3d Sortation Testing https://plasticsrecycling.org/images/Design-Guidance-Tests/APR-RES-SORT-05-2D3D-Sortation-Resource.pdf
- Compression Practice https://plasticsrecycling.org/images/pdf/design-guide/test-methods/Compression_Practice_for_Sorting.pdf
- Candidate Laboratories for Testing https://plasticsrecycling.org/images/pdf/design-guide/Resources/Candidate_Test_Labs.pdf

Test/Method Summary and Flow Diagram

The flow diagram below outlines the test process.

Determination if testing is recommended: Testing is recommended for articles that exhibit characteristics that are not predictable for the particular design feature (a "trigger"). When the trigger is met testing is recommended. Refer to the Determining Packaging Dimensions that Require 2d3d Sortation Testing document to determine if the plastic article exhibits a design feature for which testing is recommended.

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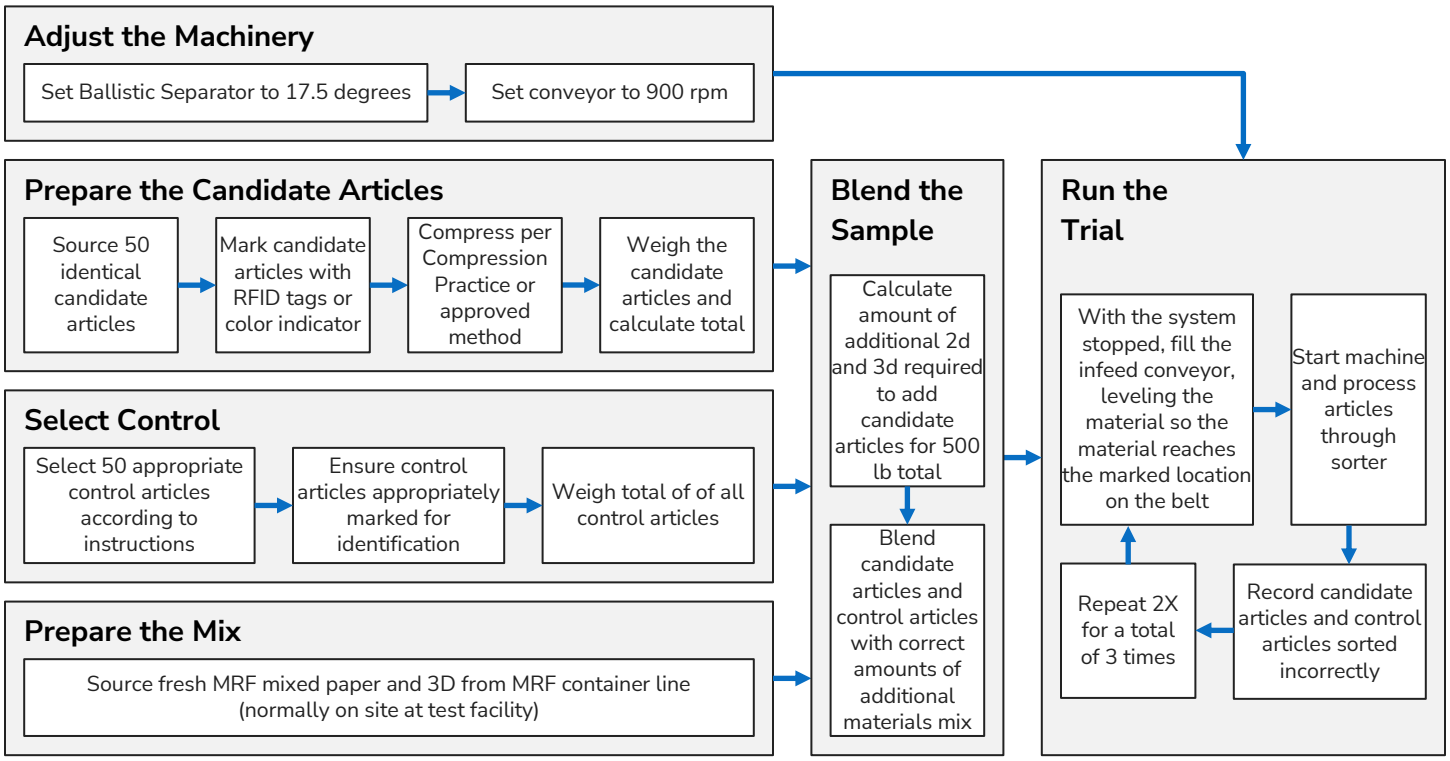
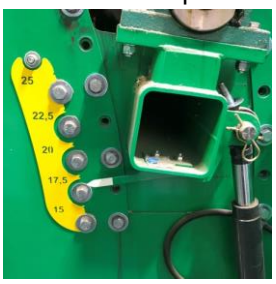


Equipment Required

1. Bottle compression device built per the instructions found at https://plasticsrecycling.org/images/Design-Guidance-Tests/APR-SORT-PR-01-compression-practice.pdf, or if the quantity justifies it, another bulk compression system to provide same results as the compression device.
2. Method of marking candidate articles for easy recognition without affecting sorting performance, i.e. RFID tags or paint.
3. Ballistic separator set to 17.5 degrees and 900 rpm infeed conveyor speed and ballistic feed conveyor set all the way toward the top of the ballistic separator.



Materials Required

1. 50 identical candidate test articles provided by the test applicant. Articles may be tested with or without caps, labels, or other components. Following the APR compression practice all caps and closures will be loosened so as to not impact compression. Articles being tested should be completely empty of any product.
2. 250 lbs. of "mixed fiber" collected from a MRF and stored in a dry location. This material is to be collected from a dry source and collected loose, prior to baling.

3. 250 lbs. of mix of plastic articles representing the plastic material commonly processed through a container line at a MRF. This material is considered the "3d" component of this test. 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.

4. 30 lbs. of Steel cans collected from the MRF Ferrous stream prior to baling
5. 40 lbs. of Aluminum (UBC) collected from the MRF UBC stream prior to baling
6. 50 Containers of the compressed applicable control chosen according to the Table 1:

Table 1: Control Articles to Be Selected According to the Candidate Test Article (Controls to Be Compressed)

Material	Size	Control Format
PET	Smaller than 3″ x 3″	8 fl. oz. PET water bottle – empty weight 15–25g
	Larger than 3″ x 3″	16.9 fl. oz. PET water bottle – empty weight 15–25g
HDPE	Smaller than 3″ x 3″	12 oz. shampoo bottle
	Larger than 3″ x 3″	
PP	Smaller than 3″ x 3″	5.3 oz. yogurt cup
	Larger than 3″ x 3″	8 oz. whipped topping tub
Paper 3D	All	64 fl. oz. gable top carton
Paper 2D	All	8.5″ x 11″ 20 lbs printer paper
Corrugated Boxes	All	8″ x 8″ x 8″
Aluminum	All	12 fl. oz. beverage can
Steel	All	10.5 oz. soup can

Method Steps

1. Select 50 Candidate test articles and 50 of the appropriate control articles.
2. Take pictures throughout the processing of the candidate test articles 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)
3. Mark the candidate articles using a clearly recognized spray paint or RFID.
4. Compress the candidate articles:
    a. If the quantity of candidate articles justifies it, compress them in bulk using an method that will provide the same results as the compression protocol i.e.: a full trash truck or a baler with reduced pressure. Contact APR prior to this.

    b. For a low quantity of candidate articles, compress the candidate articles according to the APR compression practice found at: https://plasticsrecycling.org/images/pdf/design-guide/test-methods/Compression_Practice_for_Sorting.pdf
5. Weigh the total of the candidate articles.
6. Mark the control articles in a distinguishable fashioner RFID if not already completed.
7. Weigh the total of the control articles.
8. Using the following chart, determine the amount of materials to be added to the recipe:

Table 2: Calculating Material Mix

Material	Target Comp at 2d3d	Weight of Candidate (lbs)	Weight of Control (lbs)	Weight to be added (target% x 500) – weight of control and candidate
Mixed Fiber	40%			
Aluminum (UBC)	6%			
Steel Cans	8%			
Plastic Container Mix	46%			
	100%			

For example, If testing a plastic article, the appropriate plastic control would also be selected and the following calculations would be made:

Sample of Material Mix Calculations

Material	Target Comp at 2d3d	Weight of Candidate (lbs)	Weight of Control (lbs)	Weight to be added (target% x 500) – weight of control and candidate
Mixed Fiber	40%			200
Aluminum (UBC)	6%			30
Steel Cans	8%			40
Plastic Container Mix	46%	8	9	213
	100%	8	9	483

9. Blend all materials on the infeed hopper of the machine by creating an even level of material on the feed belt up to the marked line.

10. Set ballistic Separator to 17.5 degrees, the infeed belt at 900 rpm and the feed conveyor at the top of the ballistic separator.
11. Process the material through one pass.
12. Count the number of incorrectly sorted articles for both the test article and the control articles and record on the record sheet.
13. Reblend the material.
14. Repeat steps 10–12 two additional times for a total of 3 passes.

Measurements

For each run, record the count of missorted articles from the ballistic separator.

Report Form

Found in Annex 1

Assessment

Capture rate = The percentage of test articles correctly sorted in the aggregate of the 3 test runs. (See calculations in the report form and example.)

Variance from control = The average capture rate of the control for the three test runs minus the average capture rate of the test articles for the three test runs.

If Variance is < 5%: The candidate article is most likely to be sorted correctly by 2d3d and the APR Design Guidance category for the design feature of "2d3d sorting potential" is **APR Design® Preferred**.

If Variance is >5%: A significant percentage of the test articles sort more poorly than the control. Correct 2d3d separation is preferred to avoid the more costly steps of correcting missorted articles. The APR Design Guidance category for the design feature "2d3d sorting potential" is **Detrimental to Recycling**.

Annexes

1. **Report form: 2d3d Sorting Potential of a Whole Article**
2. **Sample completed report form and calculations**

Annex 1: Report Form

2D3D SORTING POTENTIAL OF A WHOLE PLASTIC ARTICLE
Record Sheet – APR Test

Background

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

Material Mix Calculations

Material	Target Comp at 2d3d	Weight of Candidate	Weight of Control	Weight to be added (target% x 500) – weight of control and candidate articles
Mixed Fiber	40%			
Aluminum (UBC)	6%			
Steel Cans	8%			
Plastic Container Mix	46%			
	100%			

Test Results

	Missorted Test Articles	Missorted Control Articles	
Trial #1			
Trial #2			
Trial #3			**Variance:** % Recovery Control – % Recovery Test
Total			
% Recovery (150–total)/150			

Assessment

Variance	Applicable APR Recyclability Category for "2D3D 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 Report Form and Calculations

2D3D SORTING POTENTIAL OF A WHOLE PLASTIC ARTICLE
Record Sheet - APR Test #

BACKGROUND		
TESTING FACILITY		ACME TESTING
TESTING FACILITY TECHNICIAN		JANE DOE
DATE		4-Oct-23
CANDIDATE ARTICLE DESCRIPTION	Volume	2 LITER
	Label Material	N/A
	Closure material	N/A
	Body material	PET
	Brand/Description	ACME 15 X 15 X 5CM CLAMSHELL

MATERIAL MIX CALCULATIONS

Material	Target Comp at 2d3d	Weight of Candidate articles (lbs)	Weight of Control articles (lbs)	Weight to be added (target % x 500) - weight of control and candidate articles
Mixed Fiber	40%			200
Aluminum (UBC)	6%			30
Steel Cans	8%			40
Plastic Container Mix	46%	3	7	220
	100%			490

TEST RESULTS

	Missorted Test Articles	Missorted Control Articles
Trial #1	14	5
Trial #2	12	4
Trial #3	13	6
Total	39	15
% Recovery (150 - total)/150	74%	90%

Variance: % Recovery Control - % Recovery Test 16%

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%		APR Design Guide Preferred	
> 5%		Detrimental to Recycling	X

Testing Facility Technician Signature *Jane Doe*

Document Version History

Version	*Publication Date*	*Changes Made*
1	March 14, 2024	