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

Introduction – Scope, significance and use – This test is one in the series of "sorting potential test methods" developed by the Association of Plastics Recyclers

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 post consumer 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 in 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 that this test applies to automatic machinery. Plastic reclaimers also use manual sorting to remove metallic items. Before testing, the candidate article should be compared to a list of items manually removed by the reclaimer.

Technical Background

Metal separation before size reduction is conducted at the MRF and plastic reclaimer using three primary technologies.

- Magnetism: Magnets are used to remove ferrous metal and can be configured in many ways. No matter how they are configured the operating principle is the same; the article comes near or in contact with the magnet and the magnetic attraction pulls it from the material stream. Magnets are not effective in removing non-ferrous metals like stainless steel, aluminum, copper and brass.

- Eddy Current: An eddy current is an electrical field which repels conductive, non-ferrous metals such as aluminum and does not affect non-conductive materials such as plastic. When applied to a stream of material of an expected trajectory, the eddy current alters the trajectory of the non-ferrous material. The trajectory is created by flinging the mixed material off the end of a high-speed conveyor and into the eddy current field. A divider plate sits between the two trajectories and the materials are separated. Plastic articles utilizing non-ferrous metals will be subject to the eddy current force of their metal component. This force may be significant enough to place the plastic article on the wrong side of the divider plate and thus, be lost to the potential of plastic recycling.

- Metal detection: Metal detection is different than the other technologies in that it does not affect the metal component directly. Instead, it detects the component and triggers another device to divert it from the material stream. In the MRF-reclaimer process, metal detectors are primarily utilized at the plastics reclaimer in order to protect cutting machinery and improve quality. These detectors are either installed within the whole bottle optical sorter and trigger the sorters air ejectors or they are employed around a conveyor belt near the manual sorting area. Metal detectors work by analyzing the interference of an electrical field. This electrical field may be affected by extremely thin metals with large surface areas that would not otherwise damage downstream machinery just as much or more than a heavy metal item that would have catastrophic effects. Items like metalized and metallic printed labels can trigger the metal detector and must be tested to determine where they sit in relation to the threshold.

This APR Test Method provides a means for evaluating whether a metal containing plastic article will pass correctly through the MRF and plastic reclaimers metal separation process. Items containing ferrous metal are subject to a magnetic test protocol. All metallic items are subject to a metal detection protocol. An eddy current protocol is not employed since the metal detector settings are more limiting than the eddy current in the processes being modeled.

Good results in this screening test indicate that a plastic article has the potential to be sorted well automatically in production conditions. Poor results indicate that an improvement in plastic product design is desirable to promote recovery.

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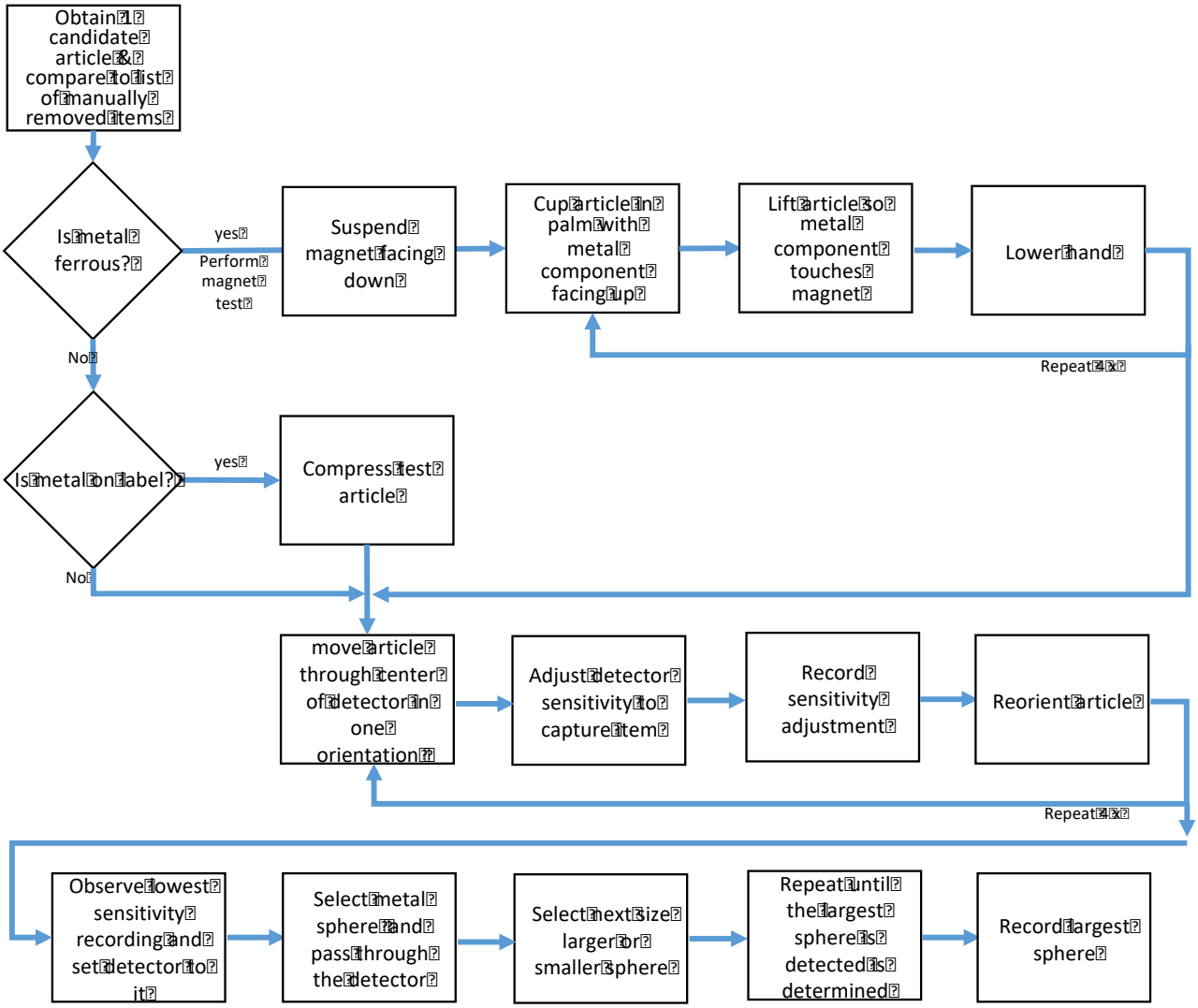
Reference Documents:

- Resource Document "Metal Sorting in the Plastics Recycling Process": https://plasticsrecycling.org/images/pdf/design-guide/Resources/Metal_Sorting_Resource_Doc.pdf
- APR Candidate Laboratories for Testing: https://plasticsrecycling.org/images/pdf/design-guide/Resources/Candidate_Test_Labs.pdf
- Compression Practice: https://plasticsrecycling.org/images/pdf/design-guide/test-methods/Compression_Practice_for_Sorting.pdf

Test/Method Summary and Flow Diagram

Plastic articles utilizing ferrous metal components are subject to the first part of this test method. The test article with the metallic component facing up is lifted so the metallic component touches the surface of a magnet facing downward. The technician then lowers his hand to determine if the magnetic force is strong enough to suspend the article. The test is conducted 5 times with the article in different orientations.

All articles containing metal, metalized or metallic printed features are subject to the second part of this test protocol which utilizes a "tunnel style" metal detector. Metallic items on flexible materials, i.e. labels and films, must first be compressed using the APR's Practice for Compressing Plastic Articles for Laboratory Evaluation (SORT-PR-01) since their shape changes in a compaction truck and shape affects the metal detection signal. The test article is placed on a non-metallic tray or conveyor belt, arranged in one direction, and passed through the center of the metal detector at a constant speed. The sensitivity of the metal detector is adjusted until the metallic item is detected. The test is then conducted with the article turned 90 degrees to the horizontal and then again, 90 degrees to the vertical. The metal detector sensitivity is then set to the lowest point observed (largest metal signature) and mild steel spheres are progressively placed in the metal detector one at a time to determine the sphere size that is equivalent to this setting. The diameter of the sphere in millimeters (mm) is the "mild steel spherical equivalent" which is compared to the industry limits. Industry limits are different for each package polymer since the recycling process are different and the limits reflect the processes.



Testing Facilities:

Please refer to APR's list of Candidate Testing Laboratories found at:

https://plasticsrecycling.org/images/pdf/design-guide/Resources/Candidate_Test_Labs.pdf

for a list of potential test locations. These companies maintain and operate pilot scale metal detection and magnetic labs. There may be a fee for evaluations.

Equipment required:

- Compression device as outlined in APR's Practice for Compressing Plastic Articles for Laboratory Evaluation found at: http://plasticsrecycling.org/images/pdf/design-guide/test-methods/Compression_Practice_for_Sorting.pdf (only required if the metal is on a flexible surface)

- Plate magnet rated at 500 gauss at the surface, 50,000 - 60,000 gauss/in^2 force index (only required for ferrous metals)

- Method to suspend the magnet facing downward (only required for ferrous metals)
- Tunnel style metal detector with an orifice large enough to pass the article through in any direction without hitting the side or top.

Materials and reagents required :

One candidate article complete with all closures attachments and labeling, empty and devoid of all product.

Method/Practice steps.

1. Obtain one empty candidate article complete with all closures, attachments and labeling. Metal and metalized tamper evident seals and rings should be in the state that they would be expected to enter the recycling stream (punctured, removed or broken, whichever is applicable).

2. Compare the candidate article to the list of metallic items manually removed from the recycling stream due to severe quality or equipment damage concerns. The list can be found at: http://plasticsrecycling.org/apr-design-guide/design-guide-resources

3. Determine if the metal is ferrous. If not, go to step 10.

4. Suspend the plate magnet with the magnetic surface facing down.

5. With your palm open and facing up, place the article in your hand with the metal component on top.

6. Raise the candidate article so that the metal containing component touches the magnet surface.

7. Pause for one second then slowly lower your hand.

8. Observe whether the article is suspended by the magnet.

9. If possible to reorient the candidate article on the tray with the metallic containing surface still pointing Up, then do so. If it is not possible to reorient it, place it in its original orientation

10. Repeat for a total of 5 tries

11. If the metal containing component is flexible, i.e. metalized label or film, then compress the article according to the APR compression protocol. Although the need for this step may not be obvious, the metal detector signature is highly dependent on the three-dimensional shape of the metal. The metal-containing component should be evaluated in the form that it will be presented to the metal detector in the field.

12. Move to the tunnel-style metal detector, preferably installed on a belt.

13. Orient the item in one direction and move it through the absolute center of the detector orifice.

14. Depending on the detector, adjust its sensitivity so that it just recognizes the item or record the signal produced by the metallic item directly.

15. Record the setting.

16. Turn the article 90 degrees in the horizontal axis and repeat.

17. Turn the article 90 degrees in the vertical axis and repeat.

18. Set the metal detector sensitivity to the lowest sensitivity of the three trials (where the candidate article appears to be the largest metal).

19. Select a metal sphere and pass it through the metal detector

20. Select the next size larger or smaller metal sphere and repeat until the largest sphere detected with this setting is determined.

21. Record this sphere diameter in mm. This is the “spherical equivalent” for the metal containing component.

22. Compare the spherical equivalent to the limit for the base polymer of the candidate article body.

Measurements: For each magnetic test, record whether the article is suspended from the magnet. For each metal detector test, record the sensitivity settings.

Report Form and Assessment follows.

RECORD SHEET FOR EVALUATION OF SORTING POTENTIAL FOR PLASTIC ARTICLES UTILIZING METAL, METALIZED OR METALLIC PRINTED COMPONENTS
APR TEST

BACKGROUND		
TESTING FACILITY		
TESTING FACILITY TECHNICIAN		
DATE		
CANDIDATE ARTICLE DESCRIPTION	Volume	
	Color	
	Label Material	
	Closure material	
	Body material	
	Metallic component	

MAGNET TEST (check one for each orientation)						
	orientation 1	orientation 2	orientation 3	orientation 4	orientation 5	Total
Suspended						(A)
Not suspended						

METAL DETECTOR TEST			
	orientation 1	orientation 2	orientation 3
Sensitivity settings			

Equivalent sphere diameter of least sensitive setting (largest metal equivalent) in mm | (B)

ASSESSMENT MAGNET TEST			
# TIMES ITEM SUSPENDED (A)		***Applicable APR Recyclability Category for "NIR Sorting Potential" (see category definitions in APR Design Guide for Plastics Recyclability Home Page)***	***Check Applicable Box***
0		APR Design Guide Preferred	
1-2		Detrimental to Recycling	
>=3		Renders Package non-Recyclable per APR Definition	

ASSESSMENT – METAL DETECTOR TEST			
SPHERICAL EQUIVALENT (B)			
PET ARTICLE	***HDPE ARTICLE***	***Applicable APR Recyclability Category for "NIR Sorting Potential" (see category definitions in APR Design Guide for Plastics Recyclability Home Page)***	***Check Applicable Box***
0-2mm	0-2mm	APR Design Guide Preferred	
>2 – <16mm	>2 – <12mm	Detrimental to Recycling	
>=16mm	>=12mm	Renders Package non-Recyclable per APR Definition	

Assessment:

This assessment classifies the tested article according to three recyclability categories defined in the APR Design® Guide for Plastics Recyclability. Please see the design guide for definitions of these categories: https://plasticsrecycling.org/apr-design-guide/apr-design-guide-home

Since the test performed is a two-stage test, final guidance issued is the most stringent of the result of the two tests. For instance, if the magnetic test guidance is "preferred" and the metal detection test is "detrimental", the result of the entire test is "detrimental".

Magnetic portion: If the number of times the article was suspended from the magnet was:

- 0 – This item is rarely removed by the magnets employed in the sorting systems and the APR recyclability category in relation to this design feature is "preferred".
- 1-2 - This item is often removed by the magnets employed in the sorting systems and the APR recyclability category in relation to this design feature is "detrimental to recycling".
- 3 or more - This item is most likely removed by the magnets employed in the sorting systems and the APR recyclability category in relation to this design feature is "renders the package not recyclable per the APR definition of recyclability".

Metal detection portion: PP/HDPE and PET recycling systems differ in their tolerance for and abilities to remove metal. Therefore, the allowable spherical equivalent differs according to the polymer from which the body of the container is constructed. If the spherical equivalent for the metallic item is as follows and used with a container constructed of:

HDPE:

- 0 – 2mm - This item is rarely removed by the metal detectors employed in the sorting systems and the APR recyclability category in relation to this design feature is "preferred".
- > 2 to 12mm - This item is rarely removed by the metal detector employed in the sorting systems but negatively affects quality, yield and operating costs of the recycler. The APR recyclability category in relation to this design feature is "detrimental to recycling".
- 12mm or more - This item is most likely removed by the metal detectors employed in the sorting systems and the APR recyclability category in relation to this design feature is "renders the package not recyclable per the APR definition of recyclability".

PET:

- 0 – 2mm - This item is rarely removed by the metal detectors employed in the sorting systems and the APR recyclability category in relation to this design feature is "preferred".
- > 2 to 16mm - This item is rarely removed by the metal detector employed in the sorting systems but negatively affects quality, yield and operating costs of the recycler. The APR recyclability category in relation to this design feature is "detrimental to recycling".
- 16mm or more - This item is most likely removed by the metal detectors employed in the sorting systems and the APR recyclability category in relation to this design feature is "renders the package not recyclable per the APR definition of recyclability".

PP: TBD

Disclaimer This document has been prepared by the Association of Plastic Recyclers as a service to the plastic packaging industry to promote the most efficient use of the nation's plastics recycling infrastructure and to enhance the quality and quantity of recycled postconsumer plastics. The information contained herein reflects the input of APR members from a diverse cross-section of the plastics recycling industry, including professionals experienced in the recycling of PET packaging articles. The information in this document is offered without warranty of any kind, either expressed or implied, including WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, which are expressly disclaimed. APR and its members accept no responsibility for any harm or damages arising from the use of or reliance upon this information by any party. APR intends to update this document periodically to reflect new developments and practices.

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