Reclay StewardEdge

Product Stewardship Solutions

City of Hamilton

Material Recovery Facility Assessment: Implementation of Recommendations for a Second Optical and Residue Quality Control Station

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1. Introduction

In 2014, Reclay StewardEdge and Stantec conducted a mass balance and container-line performance audit at the City of Hamilton's MRF. The study evaluated the flow of materials within the MRF, to develop recommendations for improving sorting efficiency and maximize capture of materials. Based on the recommendations, the City completed the following upgrades in 2016:

- Installed a new single eject optical sorter, targeting PET, directly in front of the original dual-eject optical sorter.
- Reconfigured the original dual-eject optical sorter to target plastic film (first eject) and mixed rigid plastics/polycoat (second eject). Previously this optical sorter had targeted PET on the first eject and mixed plastics/polycoat on the second eject.
- Adjusted the height of the film grabber to more effectively capture film early in the sort process.
- Added a manual residue QC sort station with three workers after the second optical sorter to sort the "negatives", as well as the residue removed from the Film and Mixed Plastics/Polycoat Optical QC lines.

In addition to the implementation of the above changes and upgrades, the City's operator Canada Fiber Ltd. (CFL) also made the following changes to the operations from the initial study:

- Closed off the first vacuum hood after the film grabber that was used for plastic film sorting at Manual Sort station #2. CFL indicated the operation of this hood created suction issues at the other two operating vacuum hoods, as well as issues at the film grabber.
- Increased the throughput of the facility to approximately 10-12 tonnes per hour from 8-10 tonnes per hours,

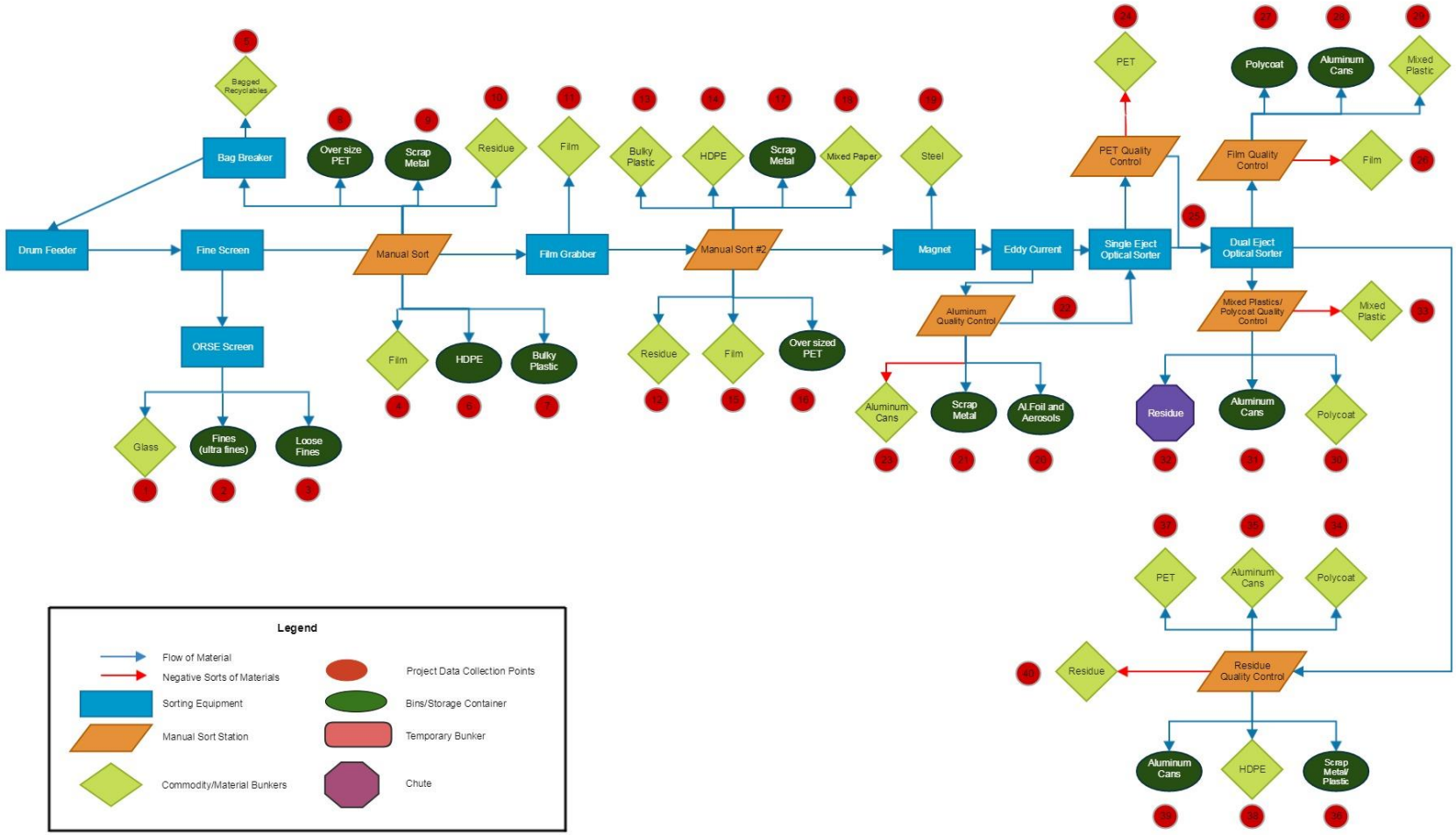
2. Methodology

Similar to the initial study completed in 2014, RSE worked with staff from the City and CFL to observe and document normal sorting operations on the Container Line. As part of this process, RSE updated the existing data points, sorting operations and process flows. This is illustrated in Figure 1: Process Flow Diagram of the Container Line.

CFL staff helped empty all bunkers and conveyor belts, and deployed several bins at each manual sort stations where materials were meant to be kept separate. RSE coordinated with City and CFL staff to introduce the test run material directly into the drum feeder. After a run of approximately 15 minutes, the line was stopped and each bunker was emptied and delivered to the sort area. Additionally, all bins that were provided to sorters were emptied, tagged and delivered to the sort site.

Note: During the audit, manual sorters at specific stations were asked to place recyclables in containers other than their normal locations. For example, film was placed in bins instead of overhead vacuum hoods. It is assumed that this change in task may have had an impact on sorting efficiency; however, it was not observed to have a material impact.

Figure 1: Process Flow Diagram of the Container Line



3. Results

3.1. Capture Rates:

After the implementation of the new equipment and changes in operation, the following results were observed and calculated:

1) Overall capture rates at the MRF increased from 77.9% to 83.5% following the upgrades undertaken by the City.
2) The capture rate of PET has increased from 73.1% to 87.2% -- this is an increase of 14.1%, and is expected to result in annual increased revenues to the facility of approximately $159,000 per year. Most of this increase is due to the installation of the PET-specific optical sorter, which has an efficiency rate of 89%; whereas previous optical sorter efficiency rate was 77%. An additional 3% of PET is captured at the Residue QC at the end of the container line.
3) The capture rate of glass increased by 2.1%, although this is not attributable to the new equipment or reallocation of manual sort staff.
4) The capture rate of aluminum cans increased by 4% (from 84.3% to 88.2%). This may be due to additional film being removed at Manual Sort station #1 and #2, which may have hidden aluminum cans. This is expected to yield an additional $43,500 per year in increased material revenues.
5) The capture rate of film plastic increased by 23.3% from 55.1% to 78.5%. A large portion of the film is removed by the film grabber and manual stations early in the sort process (64% of all film that enters the facility). The second optical sorter has a 71% efficiency rate for film, although only about 15% of the film that enters the facility is captured through the optical sorter. Another 9% of film entering the facility ends up on the residue stream just before the film grabber.

Capture Rate: The portion of targeted material captured (correctly sorted) after the sorting process, including manual sort stations, equipment, and additional QC to recover previously missed items.
Efficiency Rate: The ability of an individual piece of equipment (or sorter/sort station) to capture the targeted material type that reaches it (e.g., excludes material loss that occurs prior).
Purity Rate: The amount of *targeted* materials sorted/ejected divided by the amount of *total materials* sorted/ejected by the equipment.

However, results also indicate decreased capture rates for the following material types:

1) HDPE, by 3.9%;
2) Aluminum foil and aerosols, by 6.1%;
3) Mixed plastics, by 1.1%; and
4) Cartons, by 7.7%.

Overall capture rates, by weight, increased by 5.5%, from 77.9% to 83.5%. Considering the sum of anticipated increases and decreases in annual materials revenues based on the analysis, the MRF would be expected to achieve a net increase in materials revenues of $168,000 per year. The capture rates bolded in the table below are those that be further improved.

Table 1: Comparison of Material Capture Rates

Material Type	Capture Rate Pre-Install	Capture Rate Post-Optical Install	Absolute Difference
Glass	97.9%	100.0%	2.1%
HDPE	81.2%	**77.4%**	-3.9%
Film	55.1%	**78.5%**	23.3%
Steel	93.9%	94.0%	0.1%
Aluminum food/beverage cans	84.3%	88.2%	4.0%
Aluminum foil and aerosols	62.6%	**56.5%**	-6.1%
PET	73.1%	87.2%	14.1%
Mixed Plastics	43.1%	**42.1%**	-1.1%
Polycoat	73.6%	**66.0%**	-7.7%
Overall Capture	**77.9%**	**83.5%**	**5.5%**

3.2. Efficiency Rates

The newly installed single-eject optical sorter used for targeting PET had an almost 10% point increase in efficiency over the dual-eject optical targeting PET prior to the upgrade. Additionally, the efficiency rate has increased for the glass screen, pre-sort/film grabber/manual sort, and slightly for the eddy current. However, the efficiency of the existing dual-eject optical used for targeting Mixed Rigid Plastics (MRP) and Polycoat, which are both ejected onto the same line, saw a significant decrease in efficiency rate. MRP efficiency rate decreased from 63% to 48%, and polycoat decreased from 78% to 53%.

Table 2: Comparison of Equipment Sorter Efficiency Rates

Equipment/Sort Station	Targeted Material	Expected Efficiency Rate	Pre-Install Efficiency Rate	Post-Optical Install Efficiency Rate
ORSE Screen	Glass		92%	100%
Pre-Sort/Film Grabber/Manual Sort #2	Film		55%	64%
Steel Magnet	Steel Cans	98%	98%	98%
Eddy Current	Aluminum Cans	98%	86%	86%
Eddy Current	Aluminum Foil & Aerosol	98%	68%	69%
PET Optical	PET	90%	79%	89%
Film Optical	Film		n/a	71%
MRP Optical	Mixed Plastics		63%	48%
Polycoat Optical	Polycoat	90%	78%	53%

In addition to measuring the efficiency of the various pieces of equipment, RSE also measured the efficiency of manual sorters aimed at removing various materials throughout the sort process. During the Post-Optical Install study, two key manual stations saw a decrease in efficiency for high value commodities. Specifically, manual sorters targeting HDPE at Manual Sort #1 and Manual Sort #2 saw the efficiency of HDPE drop from 81.3% to 73.9%.Finally, the manual QC sorter on the MRP/Polycoat line saw a drop in capture of polycoat with only 75.3% of the cartons being captured from the pre-install study of 85.2%. Table 3 provides a summary of the manual sorter efficiency rates for all major material categories[1].

Table 3: Comparison of Manual Sorters Efficiency Rates

Sort Station/Target Material	Pre-Install Efficiency Rate	Post-Optical Install Efficiency Rate
Manual Sort #1		
Residue	1.4%	8.5%
Manual Sort #2		
HDPE	81.3%	73.9%[2]
Mixed Paper	16.9%	58.6%
Residue	33.7%	4.0%
Aluminum Quality Control		
Aluminum Foil and Aerosols	97.7%	97.9%
Non-Aluminum	55.2%	n/a
Single-Eject Optical QC (PET)		
Non-PET	n/a	49.7%
Dual-Eject Optical QC (Film)		
Polycoat	n/a	61.0%
Aluminum Cans	n/a	36.4%
Mixed Plastic	n/a	72.9%
Residue	n/a	20.9%
Dual-Eject Optical QC (MRP/Polycoat)		
Polycoat	85.2%	75.3%
Aluminum Cans	21.8%	25.0%
Residue	35.9%	22.0%

[1] Capture rates for smaller volume materials (e.g. scrap metal, household hazardous waste, electronics, etc.) have not been provided.
[2] In the initial study, the efficiency rate of HDPE pulled at Manual Sort #1 and Manual Sort #2 were combined together. The data has also been combined in this study for consistency purposes.

Sort Station/Target Material	Pre-Install Efficiency Rate	Post-Optical Install Efficiency Rate
Residue QC Line		
PET	n/a	42.4%
HDPE	n/a	51.1%
Aluminum	n/a	68.3%
Polycoat	n/a	61.5%

As part of the Post-Optical Install at the MRF, a residue QC line was added after the dual-eject optical. Manual sorters are capturing an additional 6% of the HDPE, 6% of the aluminum, 27% of the cartons, and 3% of the PET. The revenues from these materials, combined, is estimated to be $145,000 annually, as the table below shows:

Table 4: Material and Value Captured by Residue QC Line

Commodity	Estimated Additional Tonnes Captured	% of Commodity Captured from Post-Optical QC Sort	Revenue Attributable to Post-Optical QC Sort
PET	74	3%	$29,000
HDPE	56	6%	$34,000
Aluminum	40	6%	$69,000
Polycoat	102	27%	$11,000
TOTAL	**271**		**$145,000**

The data in the table above indicates that, without the post-optical sorter QC, the MRF would forfeit approximately $145,000 annually in revenues.

3.3. Mass Balance

Material capture rates are highly dependent on sorting equipment or manual sorter efficiency rates; however, in some case while efficiency rates may be high there are losses that occur before the material reaches the intended sort equipment or manual sorter. Table 5 summarizes the material flows and losses at each station at which the material was supposed to be targeted.

Table 5: Material Flows and Losses

Material	Equipment / Sort Station	Lost Before Sort Equipment / Station (%)	Captured (%)	Missed (%)
Glass	Fine Screen / ORSE Screen	0%	100%	0%
HDPE	Manual Sort	0%	74%	26%
Film	Film grabber / Manual Sort	0%	64%	36%
Steel	Magnet	4%	94%	2%
Aluminum	Eddy Current			
Food and beverage cans		6%	81%	13%
Foil, trays and aerosols		16%	58%	26%
PET	Optical Sorter			
#1 PET bottles, jugs and jars & #1 PET Thermoforms		5%	84%	11%
Cartons/Polycoat	Optical Sorter			
Polycoat		6%	50%	44%
Mixed Plastics	Optical Sorter			
Mixed Rigid Plastics		26%	35%	39%

3.4. Purity Rates

The purity rate of the equipment (ability to remove the targeted material, leaving other material types behind) is summarized in the table below.

In analyzing the ability of the equipment to remove only the targeted material(s), the overhead magnet and eddy current magnet perform well, with purity rates of 98.6% and 94.9% respectively. The first optical sorter (targeting PET) has a purity rate of 89.4%. The purity rate for the first eject of optical sorter #2 (film) is 48.2%. This is relatively low, and appears to be primarily due to plastic film trapping or entangling plastics and non-recyclable materials. Approximately 14% of the laminates and non-marketable plastics entering the facility, 10% of mixed rigid plastics, and 5% of HDPE containers that enter the facility are ejected by the optical film optical sort.

The second eject of optical sorter #2 targets both polycoat and mixed rigid marketable plastics other than HDPE and PET. The purity rate of this sort is 59.8%. The most significant non-targeted materials include PET, HDPE, and durable plastics. Approximately 4% of the PET and 3% of the mixed plastics entering the facility are ejected with the polycoat/mixed rigid plastics.

Table 6: Equipment Purity Rates

Equipment	Targeted Material	Purity Rate	Comments
Magnet	Steel	98.6%	Plastic film most significant non-targeted material
Eddy Current Magnet	Aluminum	94.9%	Most significant non-targeted material is steel containers, followed by other non-durable plastics and film.
Optical Sorter #1	PET Ejects opaque PET, although this material is not desired in PET bales. Manual sorters place opaque PET with MRP.	89.4%	Most significant non-targeted materials include non-recyclables, other rigid plastic containers, and film.
Optical Sorter #2	Film – First Eject	48.2%	Most significant non-targeted materials include non-targeted plastics/laminates and organic residue, other non-recyclables/residue, mixed rigid plastics, and HDPE.
Optical Sorter #2	Polycoat/Mixed Rigid Plastics – Second Eject	59.8%	Most significant non-targeted materials include PET, durable plastics, and HDPE. Also, significant quantities of non-recyclable plastics/laminates and residue,

3.5. Bunker Compositions

Table 7 summarizes the bunker composition of each of the commodities produced by the City of Hamilton. In addition, they composition of the residue generated at the beginning of the line is shown separately from the residue at the end of line. As shown in the table below, valuable container recyclables (excluding film and glass) make up about 25% of the residue. The composition of the MRP bunker shows a high percentage of valuable container recyclables having consisting of 16% polycoat, 12% PET, and 15% HDPE.

Table 7: Bunker Compositions

Commodity	Glass	Glass Fines	Pre-Sort Residue	Film	Oversized PET	Bulky Plastics	HDPE	Steel	Aluminum Food and Beverage	Aluminum Foil & Aerosols	PET	Scrap Metal	Mixed Paper	Residue	Polycoat	Mixed Rigid Plastics
Material																
Printed Paper	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	44%	7%	0%	2%
OCC/OBB	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	7%	0%	2%
Polycoat	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	2%	5%	99%	16%
PET	0%	0%	4%	2%	**100%**	1%	0%	0%	0%	0%	87%	0%	1%	3%	0%	12%
Other Plastics, Opaque PET	0%	0%	4%	2%	0%	2%	0%	0%	0%	0%	1%	0%	0%	7%	0%	32%
HDPE	0%	0%	0%	0%	0%	12%	**91%**	0%	0%	0%	2%	0%	0%	2%	0%	15%
Film	0%	0%	0%	**72%**	0%	0%	0%	1%	0%	4%	1%	0%	0%	5%	0%	1%
Bulky Plastics & Durable Plastics	0%	0%	1%	1%	0%	**85%**	3%	0%	0%	3%	0%	0%	0%	6%	0%	9%
Aluminum UBC	0%	0%	4%	0%	0%	0%	1%	0%	**99%**	0%	0%	0%	1%	1%	0%	1%
Aluminum Foil & Aerosols	0%	0%	0%	0%	0%	0%	0%	0%	0%	**55%**	0%	0%	0%	1%	0%	0%
Steel	0%	0%	6%	2%	0%	0%	1%	**93%**	0%	**39%**	0%	0%	1%	1%	0%	0%
Scrap Metal	0%	0%	0%	0%	0%	0%	0%	**5%**	0%	0%	0%	13%	0%	1%	0%	0%
Glass	**100%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Residue	0%	**100%**	**80%**	18%	0%	0%	3%	0%	0%	0%	7%	58%	2%	55%	0%	11%
E-waste	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	29%	0%	1%	0%	0%

4. Potential Improvements

In analyzing the lower/reduced capture rates of significance, the following opportunities for additional potential improvements are identified.

4.1. Polycoat

The capture rate of polycoat declined by 7.7% post installation. A significant portion of polycoat containers are being “missed” by the optical sorter, and, to a lesser extent, some polycoat materials are being mis-sorted into other material bunkers. For example:

a. The optical sorter successfully ejects about 50% of the polycoat that enters the MRF. However, the manual QC sorter that is tasked with positively picking polycoat from the QC line is missing 25% of it, which further compounds the issue.
b. Approximately 27% of the polycoat that enters the MRF is picked from the residue QC line that is located after the optical sorters.
c. An estimated 17% of polycoat entering the facility remains in residue at the end of the sort line. Smaller quantities are lost earlier in the process, including in residue and as mis-sorts by the PET optical sorter.
d. These findings may indicate that the second optical sorter may need adjusting, or is overburdened, either due to excess material or high conveyor speeds, and therefore is unable to accurately target or eject the polycoat materials.

4.2. Film plastic

The capture rate of film has increased since the changes were made to the facility, and most film is removed before the second optical sorter. The manual sorters and film grabber before the steel magnet remove approximately 69% of film, while an additional 18% of film is removed by the dual-eject optical that has been repurposed to target film. However, the existence of film along the line still appears to be impeding the visibility of other materials, and entangling some materials. It does not take a significant quantity, weight-wise, of film to impede visibility by sorters and equipment. It is suggested that the two manual sorters focusing on film removal be added back to manual sort line #2 or that MRF staff consider additional equipment to screen out plastic film.

4.3. Aluminum foil and aerosols

The capture rate of aluminum foil and aerosols has declined since the changes were made to the MRF. Approximately 58% of aluminum foil/aerosols entering the MRF is ejected by the eddy current separator (with a small quantity being mis-sorted at the QC station), 26% of the aluminum foil and aerosols end up in the residue bunker at the end of the line. A very small portion ends up in the film bunker, and in the earlier (post film grabber) residue bunker. While aluminum grade B is not a plentiful grade, particularly by weight, items like aluminum foil and pie tins can block other recyclable materials. Further, it is a material with a relatively high value. This suggests the following possibilities:

a. The eddy current magnet may need to be adjusted to better capture these materials (although it successfully ejects 80% of the aluminum cans that enter the MRF);
b. The conveyor belt speed may need to be adjusted (lowered) to allow the eddy current magnet to work more effectively; and/or

c. The eddy current magnet may be overburdened – other materials sorted later in the line (PET, Polycoat, film, and mixed rigid plastics) may be pinning aluminum down and preventing it from being ejected.

4.4. Mixed rigid plastics

The capture rate for MRP declined after the changes were made at the MRF. The Optical Sorter is only able to capture 48% of the MRP that passes through it. A higher portion of material is lost in residue off the end of the line than is mis-sorted into other categories earlier in the process. However, it should be noted that some MRP may be difficult to be identified/sorted by the optical sorter (e.g., due to certain labels, and because they contain liquids). The allocation of MRP that did not end up in the MRP bunker included (in the order of the sort line):

- Manual/film grabber film at beginning of line – 2%
- Residue at beginning of sort line – 5%
- Optical sorter #1 – PET – 5%
- Optical sorter #2 – first eject (Film) – 10%%
- Residue at end of sort line – 47%

Mixed rigid plastics, combined, account for approximately 3% of the total incoming stream, including residue.

4.5. Aluminum cans

While the capture rate for aluminum cans is relatively high, approximately 3% of the aluminum cans entering the facility end up as residue at the end of the line. There may be an opportunity to improve operations of the QC Sort line – perhaps by adding an additional sorter to target the removal of all larger materials that can block the eddy current separator. Similarly, reconfiguring the eddy current's magnetic strength may enable a greater capture rate of aluminum cans.

5. General Recommendations

1. Earlier/more targeted manual removal of large items that can block and pin materials being targeted by the magnets and optical sorters is recommended. This includes film plastic, fiber (although only a small portion of material entering the MRF is fiber, such as boxboard, magazines and newspaper, these materials can block smaller items) and larger pieces of aluminum. About 34% of the material in the residue line at the end of the sort line consists of magazines, Kraft paper, etc.
2. Slowing the conveyor speed may allow for greater manual and mechanical sorting capabilities.
3. Additional testing should be done to determine if the dual-eject optical can be repurposes to target higher value materials, PET or HDPE, instead of targeting plastic film on the first eject.

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