City of Hamilton

Review of the City of Hamilton Film Grabber System

Prepared by:

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Project Number:

60119877-114231

Date:

March, 2011

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March 31, 2011

Mr. David Yousif, Project Manager
City of Hamilton
77 James Street North, Suite 400
Hamilton, ON L8R 2K3

Dear Mr. Yousif:

Project No: **60119877-114231**

Regarding: **Review of the City of Hamilton**
Film Grabber System

We are pleased to provide a **"Final"** copy of our Film Grabber System Review Report for the City of Hamilton Material Recovery Facility at 1579 Burlington Street East, Hamilton.

This report summaries the results and findings for the two (2) monitoring sessions conducted by AECOM. The report also outlines some of the challenges encountered during the execution of the project.

We trust you will find the results of this report beneficial in terms of assessing the overall performance of the Film Grabber System.

We thank you for the opportunity to carry out this study on your behalf and look forward to working with you on future projects.

Sincerely,
AECOM Canada Ltd.

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DS:mf
Encl.
cc: Ms. Raffaella Morello, City of Hamilton

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1. Background

In 2007, Canada Fibers Limited (CFL) submitted an unsolicited proposal to the City of Hamilton (City) to upgrade the container processing system. The proposed container processing system was designed to process a minimum of 7 tonnes per hour of incoming commingled container recyclables using a combination of new conveyors and automated sorting equipment. One specific piece of automated sorting equipment outlined in the CFL proposal was the Bollegraaf Film Grabber System (FGS), designed to mechanically recover plastic films from the waste stream.

To ensure the container processing system proposed by CFL satisfies the facility's current and future operation requirements, the City retained AECOM (formerly Gartner Lee Limited) to conduct a Due Diligence Review on the container processing system. The review, completed in Fall 2007, concluded that the proposed system is complete in all aspects and that it will meet the container processing requirements for the City through to 2017.

In 2009 the City, as part of their project agreement with Waste Diversion Ontario (WDO), decided to review the performance of FGS and the Optical Sorting System (OSS). As a follow-up to the above noted Due Diligence Review project, the City retained AECOM to perform the assessment on their behalf.

The report that follows is the "City of Hamilton Film Grabber System Review". The assessment and results of the OSS review are presented in a separate report as requested by the City.

2. Performance Testing Protocol

2.1 Original Performance Testing Protocol

The performance testing protocol set out in the Terms of Reference (ToR) suggested that two (2) monitoring sessions be conducted in: July 2009 and December 2009. The months were selected to reflect the seasonality of the incoming material stream. Each monitoring session was to include processing four samples of 3 minutes worth of commingled container recyclables with the MRF operating at normal throughput speed. For each sample, a waste audit on the in-feed stream, end-product stream and residue stream was required to determine the composition, capture rate for film, purity rate for film and system throughput (expressed in kg/hour). The composition data should also include grocery/retail bag counts, and weights for plastic films accepted in the Hamilton's recycling program.

Prior to the commencement of the first monitoring session, a meeting was held between the City, CFL and AECOM to discuss the scope of work, the performance testing protocol and the schedule. During the meeting, CFL noted that testing the FGS (specifically the end product stream) would be difficult given that the plastic films recovered by the FGS and by the plastic film sorters working downstream of the FGS are pneumatically transported to the plastic film baler (via an air system). Because of this, it would be impossible to manually separate the plastic film recovered by the FGS and the plastic film recovered by the sorters since these materials all end up inside the film baler commingled.

Also, CFL noted that the FGS is a separation system which uses a combination of mechanical devices and air to remove plastic films out of the stream; however, it cannot distinguish plastic films with different plastic characteristics. In other words, the FGS is designed to capture plastic films only and cannot be programmed or configured to recover a specific type of plastic film bags unlike the Optical Sorting System, where the MRF can choose which type of container recyclables the system recovers. Considering this, the purity rate of the FGS was omitted in this report.

Finally, the grocery/retail bag count required in the original performance testing protocol was considered as too labour intensive by CFL and accordingly an alternative approach was required for the two monitoring sessions.

2.2 Revised Performance Testing Protocol

As part of the meeting noted above, an alternative auditing procedure was developed by AECOM, the City and CFL that will evaluate the OSS and FGS simultaneously. The revised testing protocol calculated the capture rate of the FGS by detangling the recovered plastic film inside the film baler. The following is a summary of the revised performance testing protocol for the FGS.

1. A single discrete load of approximately 1,000 kg for each monitoring session (this is the same load used for the OSS monitoring session). The load is collected from random areas on the container tipping floor by CFL a day before the monitoring session.
2. Process the single load under normal operating conditions (same system throughput and number of staff as normal processing operation).
3. During the processing of the sample load, AECOM performed time and motion study on the four sort staffs recovering plastic films downstream of the FGS. These sort staff are responsible to recover any plastic films missed by the FGS and place it beneath the film suction system that transports the film into the film baler. Assuming that each hand-picking motion by the sorter is equivalent to the recovery of a single plastic film, AECOM recorded the performance of each film sort staff (using a timer and a hand tally) over a 5 minute interval.
4. The data collected from the time and motion study was then extrapolated (using the actual time required to process the discrete load sample) to calculate the total number of hand-picking motions performed by each sort staff. The total number of hand-picking motions is equivalent to the number of bags recovered by the sort staff during each monitoring session.
5. The quantity (weight) of plastic films recovered by the sorters was calculated by first determining the average weight of a single plastic film bag. To achieve this, AECOM prepared four representative plastic film samples (each containing 30 random plastic film bags) and recorded their weight using the digital weigh scale provided by the City. The average weight of the four plastic film samples was then divided by 30 (the number of plastic film bags inside each sample) to determine the average weight of a single plastic film bag. Finally, the weight of a single plastic film bag was multiplied by the total number of hand-picking motions of the four sort staff stationed downstream of the FGS (item 4) to come up with the total weight of plastic films missed by the FGS.
6. After the discrete load was processed, the material inside the film baler was transferred into wheeled plastic carts where it is weighed using the floor weigh scale at the MRF.
7. The total weight of the plastic film recovered inside the film baler was then subtracted by the total weight of plastic film recovered by the sorters (item 5) to determine the quantity of plastic film captured by the FGS.
8. The total number of plastic film bags captured by the FGS was determined by dividing the total weight of plastic films recovered by the FGS (item 7) by the average weight of a single plastic film bag.
9. The capture rate was calculated by dividing the total weight of plastic film recovered by the FGS (item 7) by the total weight of plastic film inside the film baler (item 6).
10. The quantity (weight) of plastic film recovered by the FGS (item 7) was extrapolated to one hour to determine the system throughput (kgs/hour).

Selected photographs taken during the monitoring session are provided below.

Single Discrete Load

Film Grabber System

Staff Removing the Plastic Film Bags Inside the Film Baler

Collected Plastic Film Bags From Inside the Film Baler

30 Random Sample Bag

30 Random Sample Bag Placed Loosely on the Ground

2.3 System Monitoring Parameters

For each of the two monitoring sessions, AECOM determined the recovery rate and system throughput by analyzing the data gathered at the MRF. A definition of capture rate and system throughput is provided below.

1. **Capture Rate** – A measurement of the quantity of items that were successfully recovered by the FGS. This is calculated by dividing the weight of the recovered material by the FGS by the total weight of material available for recovery. For example, if FGS was able to recover 10 kg of plastic film out of the total 20 kg of plastic film available in the inbound material, the capture rate of the FGS will be 50%. The recommended capture rate for the Hamilton FGS, as suggested in the CFL container processing line upgrade proposal, is approximately 30%.
2. **System Throughput** – The total quantity of material the FGS is capable of processing in an hour. The throughput of the FGS is expressed in kgs/hour.

2.4 System Performance Consideration

It should be noted that there are numerous operating conditions that can affect the performance, and ultimately, the capture rate of the Film Grabber System. These include:

1. **Throughput of the Processing System** – The throughput (expressed in tonnes/hour) of the overall processing system will have a direct impact on the performance of the FGS. As the throughput increases, the overall quantity of material entering the FGS also increases making it more difficult for the fingers inside the drum to grab (separate/remove) the plastic film from the other materials.
2. **Inbound Material Composition** – The inbound material composition has a dramatic impact on the performance of the FGS. A FGS installed in a single stream MRF will most likely yield a lower capture rate than a FGS installed in a dual (two) stream MRF. A single stream MRF processes container and fibre materials commingled and therefore the FGS is subjected to a higher quantity of contaminants (i.e., large Old Corrugated Cardboards) that might impede the fingers inside the drum from grabbing the plastic films properly and consequently impact the performance of the system.
3. **Seasonality** – Winter months and spring/fall seasons typically produce inbound materials that are denser, moist and often times stuck together. During these months, the plastic film is more prone to be stuck with other materials making it difficult for the fingers inside the drum to grab the plastic film. Also, plastic film that is moist tends to be heavier and is more difficult for the air system to blow the plastic film towards the fingers inside the drum.

Generally speaking, it is unknown under what operating conditions the recommended capture (approximately 30%) specified by the FGS manufacturer (Bollegraaf) was based on. The manufacturer's recommended capture rate is most likely determined under ideal operation conditions (i.e., slower system throughput, material composition that contains less contaminants (unwanted material) and more of the targeted material (plastic film) whereas the actual capture rate achieved by the system is based on operation conditions that are not ideal and might negatively impact the recovery capability of the system. In another words, the discrepancy between the recommended and the actual capture rate achieved by the FGS is most likely a result of the different operations conditions that the system was performing under when tested by the manufacturer and in real operation.

3. Performance Testing Results

All of the monitoring sessions were all conducted on Friday. As explained by CFL, the City's container processing line typically operates from Monday to Thursday which left Friday as the only day available for the system sessions without affecting normal processing operation. To ensure that the data gathered during each monitoring session was representative of normal operations, CFL confirmed that the staffs used during normal processing operation (Monday to Thursday) were the same staffs used for the two FGS monitoring sessions.

The two FGS monitoring sessions took place on:

1. Session 1 – October 9, 2009; and
2. Session 2 – February 26, 2010.

3.1 Overall Processing Time

Initially, AECOM was advised by CFL that it will take approximately 15 minutes to process the 1,000 kg sample load and therefore the processing time for the first session was recorded as 15 minutes. However, during the first monitoring session, it was noted that the actual time required to process the 1,000 kg was less than 15 minutes. In light of this, it was agreed (between AECOM and CFL) that the time recording for the monitoring session would commence when the first piece of material was found flowing through the OSS and stop when the CFL Supervisor signalled there was no materials inside the glass trommel screen (located at the front of the processing system). The total time recorded by AECOM will constitute the total time required to process the 1,000 kg sample load. A summary of the overall processing time for the two FGS monitoring sessions is listed in Table 1 below.

Table 1. Processing Time for Each Monitoring Session

Monitoring Session	Date	Processing Time
Session #1	October 9, 2009	15 minutes
Session #2	February 26, 2010	11 minutes 39 seconds

3.2 Performance of the Plastic Film Sorters

The performance of the plastic film sorters (Table 2) and their relative position to the FGS is presented below.

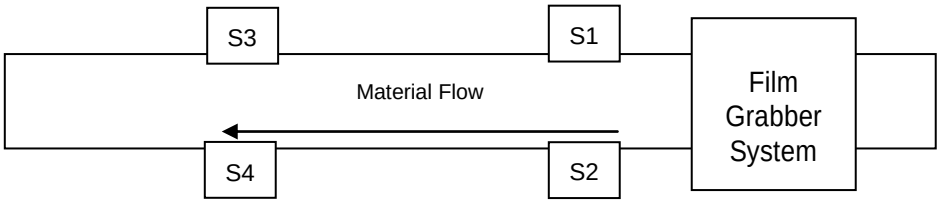

Table 2. Processing Time for Each Monitoring Session

	Monitoring Session #1		Monitoring Session #2	
	Number of Motions Per 5 Minute Interval	***Total Number of Motions for the Sample Load (15 minutes)***	***Number of Motions Per 5 Minute Interval***	***Total Number of Motions for the Sample Load (11 mins 39 secs)***
Sorter 1 (S1)	106	318	128	298
Sorter 2 (S2)	125	375	101	235
Sorter 3 (S3)	59	177	83	193
Sorter 4 (S4)	101	302	88	205
Total	390	1,171	400	932

As noted in the table above, the total number of motions (picks) performed by the sorters over the 5 minute interval in session #1 and #2 are consistent (390 and 400 motions per 5 minute for session #1 and #2 respectively). The difference in the overall total number of motions for the two sessions is a result of extrapolating the sorter's number of motions based on the overall processing time for each monitoring session. Given that the first monitoring session took approximately 3 minutes and 21 seconds longer than the second monitoring session, the number of motions performed by the sorters in the first monitoring session is higher.

Considering the foregoing and to ensure the FGS was evaluated accurately, AECOM reviewed the processing time of two OSS monitoring sessions (in which the FGS was in operation but not reviewed) and the processing time of the second FGS monitoring sessions to determine the average processing time typically associated to processing the 1,000 kg discrete sample load. Based on the review, the average processing time was approximately 11 minutes and 58 seconds. Assuming the 1,000 kg sample load for the first FGS monitoring session required 11 minutes and 58 seconds; AECOM recalculated the total number of motions performed by the sorters during the first FGS monitoring session. The results are provided in Table 3 below.

Table 3. Revised Processing Time for the First Monitoring Session

	Monitoring Session #1		Monitoring Session #2	
	Number of Motions Per 5 Minute Interval	***Total Number of Motions for the Sample Load (11 mins 58 secs)***	***Number of Motions Per 5 Minute Interval***	***Total Number of Motions for the Sample Load (11 mins 39 secs)***
Sorter 1 (S1)	106	254	128	298
Sorter 2 (S2)	125	300	101	235
Sorter 3 (S3)	59	141	83	193
Sorter 4 (S4)	101	241	88	205
Total	390	937	400	932

The table above shows that if the average processing time for the 1,000 kg sample load was approximately 12 minutes, the number of motions that the sorters perform in each of the two FGS monitoring session are almost identical.

3.3 Average Weight of a Plastic Film Bag

As described earlier in the report, the weight of a single plastic film bag was determined by preparing four bag samples each containing 30 random plastic bags. The average weight of the four bag samples was then divided by 30 to determine the average weight of a single plastic bag. The following table presents the average weight of a single bag used for each of the two monitoring sessions.

Table 4. Average Weight of a Single Plastic Film Bag

	Monitoring Session #1	Monitoring Session #2
Bag Sample	***Average Weight of a Single Bag (kgs)***	***Average Weight of a Single Bag (kgs)***
1	0.0150	0.0154
2	0.0091	0.0154
3	0.0236	0.0151
4	0.0132	0.0181
5*	N/A	0.0203
Average Weight of a Single Plastic Film Bag (kgs)	**0.0152**	**0.0169**

*Note: * An additional bag sample was prepared and recorded during the second monitoring session.*

3.4 Capture Rate, and System Throughput Summary

The capture rate and system throughput calculated for each of the two monitoring sessions are summarized in Table 5 below.

Table 5. Summary of the FGS Monitoring Sessions

	Monitoring Session #1		Monitoring Session #2	
Film Recovery	***Weight (kgs)***	***Count****	***Weight (kgs)***	***Count****
Film Grabber System	26.21	1,725	8.27	490
Plastic Film Sorters	17.79	937**	15.73	932
Film Found in Other Areas	1.32***	87***	0****	0****
Total	***45.32***	***2,982.49***	***24.00***	***1,422.34***
Capture Rate	**65.7%**		**34.4%**	
System Throughput (kg/hour)	**119**		**43**	

*Note: * Calculated by dividing the total weight of plastic film recovered by the average weight of a single bag for each monitoring session (i.e., 26.21 kg / 0.0152 kg = 1,725 plastic film bags).*
*** Based on the average processing time of 11 minutes and 58 seconds.*
**** Plastic film found in the Mixed Plastic OSS storage bunker.*
***** The quantity of plastic film found in other areas was insignificant.*

As shown in Table 5 above, the overall quantity of plastic film in the sample load for monitoring session #1 and #2 differed significantly. After reviewing the data, AECOM was not able to explain the discrepancy in the quantity of plastic film between the two monitoring sessions since a composition audit of the sample loads was not completed.

The quantity of plastic film recovered by the plastic film sorters was consistent between the two monitoring sessions. As indicated in Table 3 of this report, the number of hand motions (picks) was almost identical during a 5 minute interval. Further, extrapolating the data by the overall processing time also suggested that the number of hand motions from the two FGS monitoring sessions are consistent (based on the calculated revised average processing time for monitoring session #1). In light of this, it can be said that the performance of the plastic film sorters is not dependent on the capture rate of the FGS but rather the number of motions the sorters are able to perform consistently. In other words, the quantity of plastic film recovered by the sorters will be the same regardless of the FGS achieving a 50% capture rate or a 10% capture rate.

The capture rate achieved by the FGS in monitoring session #1 and #2 also differed significantly (approximately 31% variance). Given that the quantity of plastic film recovered by the sorters is almost the same in the two monitoring sessions, the higher capture rate achieved in session #1 is most likely a result of a higher quantity of plastic film available in the sample load.

Notwithstanding the foregoing, the capture rate for each of the monitoring sessions (66% and 34% in monitoring session #1 and #2 respectively) was above the capture rate (30%) recommended by the equipment, suggesting that the FGS is performing efficiently. This conclusion was supported by the fact that there were very limited amounts of plastic film observed by AECOM in other areas of the container processing line during the two monitoring sessions.

3.5 End Market Comment

In order to further validate the performance of the FGS, AECOM contacted the end market for the recovered plastic film and inquired about the quality of bales produced by the City. The end market contacts/information was provided by the City. The comments from the end market are provided in Table 6 below.

Table 6. Summary of Comments by the End Market

Monitoring Session	Mixed Plastic and Films
	EFS Plastics
Session #1	For film bales, it is estimated that approximately 60-65% is plastic film, 10% is paper, and the rest (25-30%) is metal, aluminum material.
Session #2	End market did not have information on the plastic film bales produced by the City.

4. Additional Information on the FGS

4.1 Capital Equipment Cost

The overall cost of the new container processing line was in the order of $2.7 million dollars. From that, approximately $529,000 was for the Bollegraff Film Grabber System.

4.2 Operation Savings

Overall, the container processing system has resulted in operation savings for both the City and the CFL. The number of sorters required to operate the processing line was reduced from 17 sort staff to 11 sort staff after the system upgrade (a 40% decrease).

It should be noted that determining how much staff reduction was attributed to the installation of the FGS is not possible at this time. In discussion with CFL, the difficultly arises from the fact that the MRF underwent an entire processing system upgrade (the upgrade also included new conveyors, an optical sorting system and general reconfiguration of the sort process) in which the FGS was only one component of the entire system. In other words, there is no baseline to reference exactly how many sorters were required before and after the FGS installation since the old system configuration was completely different from the new (current) system.

4.3 Maintenance Requirements

From speaking with CFL, there are very limited amounts of maintenance required for the FGS. Staff working at the facility is only required to perform preventative maintenance on the FGS to ensure maximum material recovery.

4.4 Health and Safety Issues

There were no health and safety issues related to the FGS observed during the monitoring sessions or reported by CFL. The rotating mechanism of the FGS is contained inside a metal casing which prevents staff from being exposed to the interior mechanical recovery components of the system. The operation of the FGS can be considered safe and will not impose any health and safety risks for staff working around the system.

5. Lessons Learned

The following is a list of lessons learned during the FGS review.

1. **Future Testing** – Future testing of the FGS should be MRF specific. The original testing protocol proposed in the ToR (processing four samples of three minutes worth of material with the MRF operating at normal throughput speed) was not practical/possible given the recovered plastic films by the FGS and the plastic film sorters are transported directly into the film baler. Performing the original testing protocol is very labour intensive and time consuming since the film baler would have to be emptied four separate times.
2. **Larger Sample Load** – As noted earlier in the report, the total quantity of plastic film available in the sample load differed significantly between the two monitoring sessions (45.32 kg for session #1, 24 kg for session #2). The discrepancy might be the fact that the composition of the sample load was not truly representative of the quantity of plastic films typically available for processing. In light of this, it is proposed that a larger sample load (perhaps 2,000 to 3,000 kgs) be used in future FGS testing to ensure that the recorded data are consistent.
3. **Waste Composition Audit of the Sample Load** – Future testing of the FGS should include a waste composition on the sample load as a means to verify the quantity of plastic films available prior to the monitoring session. By doing this, the quantity of plastic films recovered by the FGS and the sorters downstream of FGS can checked against the quantity of plastic film in the sample load before processing for consistency.