New York State Pollution Prevention Institute
Rochester Institute of Technology

Final Report for:

Tristar Ltd.

Buffalo, New York

July 14, 2014

EDG-trac Knife Advance System Performance Evaluation

Prepared for:
Hubert Jeras
President
Tristar, Ltd.
265 Mayville Avenue
Buffalo, New York 14217
Phone: (716) 873-0081
Fax: (716) 873-0154
Email: sales@tristarltd.com

Prepared by:
New York State Pollution Prevention Institute (NYSP2I)
Rochester Institute of Technology
111 Lomb Memorial Drive
Rochester, New York 14623-5608
Phone: (585) 475-2872
Fax: (585) 475-6610
Web: http://www.nysp2i.rit.edu
E-mail: nysp2i@rit.edu

The New York State Pollution Prevention Institute (NYSP2I) at the Rochester Institute of Technology (RIT) conducted an independent product performance evaluation for Tristar Ltd. Results of this evaluation are provided in this final project report.

This report is prepared consistent with the terms and purposes of the New York State Pollution Prevention Institute Agreement between Tristar Ltd. and Rochester Institute of Technology, effective March 25, 2014, and funded in part by the New York State Department of Environmental Conservation by the NYSP2I Green Technology Accelerator Center (GTAC) program. All conclusions herein are subject to the research warranty and liability limitations, and other provisions, described in the research agreement executed by RIT and Tristar Ltd. (the “Parties”). Any opinions, findings, conclusions or recommendations expressed are those of the author(s) and do not necessarily reflect the views of the Department of Environmental Conservation.

This report has been approved by the parties for Tristar Ltd.’s external use if it is used in its entirety. Any other use must be agreed to in writing by the authorized signatories of the Parties. In addition, neither Party will use the name of the other in connection with any products, promotion, or advertising without the prior written permission of the other Party.

Table of Contents

Executive Summary

This report documents the work completed by the New York State Pollution Prevention Institute (NYSP2I) at the Rochester Institute of Technology (RIT) to assist Tristar Ltd. (Tristar) in evaluating the performance of Tristar Ltd.'s EDG-trac Knife Advance System at a customer site. This project was supported by NYSP2I's Green Technology Accelerator Center (GTAC), a program created to assist New York State companies with developing and commercializing green technology. Tristar is a manufacturer of fabricated components and equipment, including remanufactured filtration systems. Remanufacturing is an important means of extending the life of a product and reducing environmental impacts.

The goal of this project was to evaluate product claims regarding improved energy use and separation efficiency of a remanufactured rotary vacuum filtration system that utilizes Tristar's EDG-trac Knife Advance System. It was anticipated that improvements over the design of conventional systems, such as the use of a single motor gearbox and control based on motor frequency versus drum rotation, would result in improvements in energy use, water use, sludge moisture content and throughput. This study focused on quantifying operational parameters related to these anticipated improvements.

Tristar made arrangements with PeroxyChem LLC (PeroxyChem) to conduct this study at PeroxyChem's facility in Tonawanda, NY. PeroxyChem was replacing two older rotary vacuum filters with two remanufactured filters built by Tristar. The schedule for the replacement allowed for direct measurement of the performance of an operating rotary vacuum filtration system followed by a similar analysis of the remanufactured rotary drum filter with which it was replaced. The parameters that were analyzed and compared during this evaluation included energy use, filtration rate, sludge moisture content and effluent quality.

Two batch filtration tests were run for each system (old system and Tristar's remanufactured system). The most significant differences in performance observed were that the Tristar system: 1) had a higher throughput, i.e. filtered the water at a much higher flow rate (7 times faster on average) and 2) consumed 12.6% of the energy used in the old system, on a per gallon filtered basis. The increase in throughput was largely attributed to the effectiveness of the knife advance system. The difference in energy requirements was, therefore, also linked to the performance of the knife advance system. The increase in processing times reduced the energy

demand per batch by the vacuum pump, which was the largest energy consumer. Effluent quality showed little difference between the removal efficiency of the two systems (TSS ranging from 100 to 200 mg/l). The water content in the sludge cake produced by the Tristar system was slightly higher; the difference in sludge water content was attributed to the speed of drum rotation which can be adjusted to create drier sludge.

This project with Tristar Ltd. was supported by NYSP2I's Green Technology Accelerator Center (GTAC), a program supported by the New York State Department of Environmental Conservation (NYSDEC).

1. Introduction

Tristar is a manufacturer of fabricated components and equipment, including remanufactured filtration systems. The EDG-trac Knife Advance system ("EDG" stands for "encoded digital guidance") is an ancillary system for a rotary vacuum filter, which consists of an advancing knife and associated controls. Rotary vacuum filters are used to separate solids from a liquid. In these systems, the slurry to be filtered is contained in a trough located just below the filter drum. As the drum rotates through the slurry, the liquid is pulled through the filter media on the surface of the drum via a vacuum pump and discharged through the center cavity of the drum. Accumulated solids are cut away from the surface using an advancing knife (see Figure 1). A P&ID that describes how a filtration system equipped with the EDG-trac Knife Advance is typically configured can be found in Appendix 1.

Figure 1: EDG-Trac Knife Advance System

The EDG-trac Knife Advance system makes use of a single motor gearbox for slow forward/reverse, fast forward/reverse finite control that responds to changes in motor frequency. This design feature allows for infinite turndown speed and control. Traditional systems employ a dual motor design to achieve complete control. The New York State Pollution Prevention Institute (NYSP2I) at the Rochester Institute of Technology (RIT) evaluated the performance of Tristar Ltd.'s (Tristar) EDG-trac Knife Advance System at a customer site. The goal of this project was to evaluate product claims regarding improved energy use and separation efficiency for a remanufactured rotary vacuum filtration system that utilizes the EDG-trac Knife Advance system. It was anticipated that design improvements over more conventional systems, such as the use of a single motor gearbox and control based on motor frequency versus drum rotation, would result in improvements in energy use, water use, sludge moisture content and throughput.

This project was supported by NYSP2I's Green Technology Accelerator Center (GTAC). The intent of the GTAC program is to assist New York State companies with developing and commercializing green technology. The objective of this assistance is to promote job creation and retention, economic development, the introduction of innovative green products and technologies to the marketplace, and new and/or expanded business enterprises.

2. Project Plan

The major project tasks performed are described below. All technical tasks and resulting data were subject to the scientific limitations of the instrumentation, test samples, and the test facility.

The selected test location for this project was PeroxyChem, LLC (PeroxyChem). At the time that the project was initiated, PeroxyChem's facility in Tonawanda, NY had two operating rotary vacuum filters. These filters were used to dewater the sludge produced when a primary filtration system (used directly to purify a process solution) was backwashed. Recovered water was returned to a holding tank for reuse in the primary filtration system. The rotary vacuum filters were typically used once every other day for 12 – 24 hours. Both filters were OEM equipment (Komline-Sanderson and Ametek) and had been in service for more than 10 years. PeroxyChem was in the process of replacing these systems with two remanufactured rotary vacuum filters from Tristar. The schedule for the replacement program allowed for a straightforward comparison of the two different rotary vacuum filtration systems on the same process line. The old system was still in operation when the project commenced, and the remanufactured EDG-trac system was installed in the middle of the project; data was taken and analyzed for both systems per the tasks described below.

Task 1: *Performance Criteria Defined*

NYSP2I worked with both Tristar and PeroxyChem to define the operational parameters that would be measured during the study. These parameters were selected to meet two primary objectives: (1) to demonstrate that the remanufactured systems supplied by Tristar meet PeroxyChem's performance expectations and (2) to provide baseline data that can be used to support product-related environmental claims being made by Tristar.

Based on a meeting with Tristar and PeroxyChem, the following operational parameters were agreed upon:

Electric Energy Usage

Each of the following four motors/mechanisms was measured separately. Total electric use for the entire filter system was calculated using the data for the individual motors.

1. Agitator drive – The motor and mechanism that moves the agitator in the vat.
2. Drum drive – The motor and gearbox that rotates the filter drum.
3. Knife Advance – The mechanism that removes the filter cake and exposes a fresh layer of pre-coat.
4. Vacuum pump

Filtration Performance

1. Volume treated per batch
2. Time to filter a batch
3. Filter aid (pre-coat) consumption (lbs./batch)
4. Cake dryness
5. Total solids disposed (lbs.)
6. Filtrate quality (measured as Total Suspended Solids)

In order to evaluate filtrate quality, NYSP2I sent samples of system effluent to an external laboratory for analysis.

Task 2: *Baseline Data Measurements*

Of the two operating rotary vacuum filters at PeroxyChem, it was decided to measure the baseline performance of the “LAP” filter because it would be directly replaced with a remanufactured Tristar system during the study period. The advancing knife on this filter was manually advanced by the operators. Data on the performance of the LAP system was collected as defined by the parameters selected under Task 1, for 2 operating cycles. Sampling dates and other relevant information can be found in the Data Log Sheet (Appendix 2). Water samples (before and after filtration) were taken twice during each batch run and analyzed for total suspended solids (TSS). Sludge cake samples (solids removed from the rotary drum that contain both pre-coat and filtered solids) were also taken at the same time. To determine solids content of the sludge cake, wet samples were weighed, dried in an oven at 105 degrees Celsius for 24 hours, and weighed again. Energy use was monitored using a power data logger (Dent

Elater SP) on the vacuum pump and various drives as described in Task 1. This data provided baseline data to be compared with the performance of the remanufactured systems (Task 3).

Task 3: ***Performance Measurements of Remanufactured Equipment***

After Task 2 was completed and the LAP system was replaced with the Tristar remanufactured system, NYSP2I and PeroxyChem collected data regarding the performance of the Tristar system, as defined by the same parameters selected under Task 1, for 2 operating cycles. Sampling dates and other relevant information can be found in the Data Log Sheet (Appendix 2). Water samples (before and after filtration) were taken twice during each batch run and analyzed for total suspended solids (TSS). Sludge cake samples (solids removed from the rotary drum that contain both pre-coat and filtered solids) were also taken at the same time. To determine solids content of the sludge cake, wet samples were weighed, dried in an oven at 105 degrees Celsius for 24 hours, and weighed again. Energy use was monitored using a power data logger (Dent ElitePro SP) on the vacuum pump and various drives as described in Task 1. The information obtained was then used to compare with performance of the older system (Task 2).

3. Results

As described in Section 2, data was collected during two batch runs for each system, the older rotary vacuum filter called “LAP” and the new remanufactured Tristar system. Key tasks and events were documented in the log sheet (Appendix 2). All the testing was performed without any major issues. The results have been tabulated and are summarized in Table 1.

Table 1: Summary of Results

				1	2	3	4	5	6	7	8	9	10
Filter Sampled	Batch Time Period	Date Sampled	Effective Level Filtered	Volume Treated (gal)	Total Batch Time (h)	Ave. Flow Rate (gal/h)	Precoat Used (lb)	Initial TSS (mg/L)	Final TSS (mg/L)	% Removal	% Solids of Sludge Cake	Total Solids Disposed	Total Solids Removed
LAP	**4/28/2014 - 4/29/2014**		**29.4%**	**676.04**	**27.67**	**24.43**	**12.5**			**98.31%**	**56.38%**	**78**	**65.5**
		4/28/2014						11000	110	99.00%	55.46%		
		4/29/2014						8000	190	97.63%	57.30%		
LAP	**4/30/2014 - 5/3/2014**		**69.6%**	**1600.65**	**59.83**	**26.75**	**25**			**97.56%**	**54.85%**	**196**	**171**
		4/30/2014						7400	210	97.16%	51.40%		
		5/1/2014						5900	190	96.78%	55.77%		
		5/2/2014						12000	150	98.75%	57.37%		
NEW FILTER INSTALLED BETWEEN 5/5/2014 AND 5/9/2014													
TRISTAR	**5/22/2014-5/23/2014**		**137.7%**	**3168.20**	**21.75**	**145.66**	**25**			**97.15%**	**50.34%**		
		5/22/2014						4900	120	97.55%	46.75%		
		5/23/2014						8300	270	96.75%	53.93%		
TRISTAR	**6/2/2014-6/3/2014**		**129.4%**	**2976.05**	**13.75**	**216.44**	**25**			**95.91%**	**49.34%**	**369**	**344**
		6/2/2014						3800	180	95.26%	49.96%		
		6/2/2014						5800	200	96.55%	48.72%		
				Ratio of Ave Tristar to LAP Flow Rates		**7.07**			Average % Solid Comparison		LAP-55.61%, Tristar-49.84%		

The key results used to compare the performance of the LAP and Tristar systems can be found in Columns 1 through 8 of Table 1. Hydraulic, water quality and sludge cake dryness data are included in these columns for all four batch runs. After the Tristar system was installed as a replacement for the LAP filter, it was immediately noticed that flow rates were significantly higher through the remanufactured Tristar system than through the LAP system. The ratio of average filtration flow rates from Column 3 was calculated to be around 7. For the same process solution, the Tristar rotary vacuum drum system was able to filter on average 7 times faster than the original LAP system. This much faster rate correlates to more solution being filtered over a shorter period of time (Columns 1 and 2) and can be directly attributed to the effectiveness of the knife advance system. With the installation of the remanufactured system, PeroxyChem did, however, also make a change to the process by which they applied the pre-coat to ensure that it was more evenly applied to the drum. The fact that with there was a 1:1 relationship between the pre-coat applied (lbs.) and the total solids removed in the case of both filtration systems supports the conclusion that it was largely the efficiency of the knife advance system, rather than the change in the uniformity of the pre-coat, that lead to the increase in filtration rate.

In terms of water quality, removal efficiencies as measured by total suspended solids (TSS) were similar and within statistical consistency (Columns 5 to 7). Cake dryness was compared and the Tristar system produced sludge cake that had lower average solids content than that of the sludge cake produced by the LAP system (Tristar – 49.84% solids, LAP – 55.61% solids). It was later determined that the dryness of the sludge is dependent on the speed of the rotating drum, as the cake spends 2/3 of the drum's revolution drying. Differences in the drum speed between the two systems were not recorded during the study, but this result suggests that this variable could be further optimized for the remanufactured system to produce a dryer sludge cake.

Energy was monitored on separate components for each system. A breakdown of the measurements can be seen in Appendix 3. Over the course of the operating cycles evaluated, the power meter was moved consecutively from one component to another as shown graphically in Figure 2. Although not necessarily measured for an entire batch, it was assumed that, in all cases, the power draw of the components was constant over the entire cycle time. For the Tristar system, the agitator drive, drum drive and automatic knife advance system were measured at a central loaction and are designated as "New Filter" on the graph.

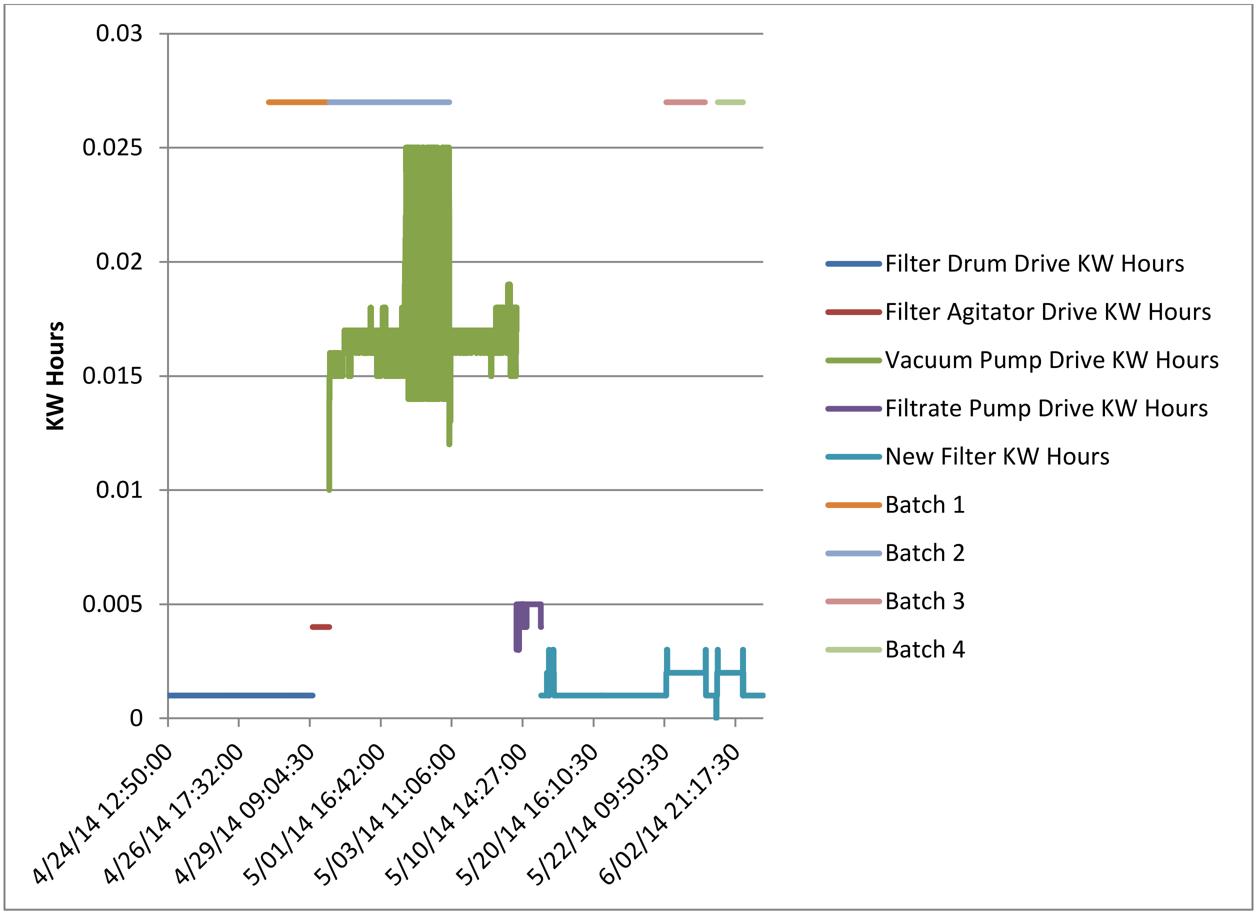


Figure 2: Measured Energy Demand for System Components

The same filtrate and vacuum pumps were used in both filter systems (i.e. these pumps were not replaced). Of all the components of the filter system, the vacuum pump requires the most power. To determine the energy expended per gallon processed, information from the data logger was first used to calculate an average power draw for each component and is shown in Table 2.

Table 2: Average Power Draw for Each System

Component	**System(s)**	**Avg. KW**
Filter Drum Drive	LAP	0.1048
Filter Agitator Drive	LAP	0.4785
Vacuum Pump Drive	LAP/Tristar	2.1103

Component	System(s)	Avg. KW
Filtrate Pump Drive	LAP/Tristar	0.5475
Filter Drum Drive, Agitator Drive and Knife Advance	Tristar	0.1305

Based on hydraulic information collected in Table 1, *energy per gallon filtered* could be calculated. For example, the energy per gallon for the vacuum pump drive was calculated for the Tristar system as follows (Batch 3 in Appendix 3):

(Ave. KW from Table 2) x (time to process batch) / (total volume processed), or

(2.1103 KW) x (21.75 hours) / (3168.2 gallons) = **0.0145 KWH/gal**

which is the value shown in the appropriate cell in Appendix 3 (cell highlighted in red color).

For the batches evaluated during this study, the energy per gallon needed to filter the process solution was significantly lower for the Tristar system (0.0160 KWH/gal versus 0.1269 KWH/gal). The reason for this difference can be readily explained. The Tristar system was not in operation as long as the LAP system because of the faster filtration rates (higher gal/hour processing rate), thus reducing the energy utilized per batch by the vacuum pump, which was the most significant energy user.

Another way to compare and visualize energy/gal ratings for each system is to normalize the two results where the higher value (old system) is set equal to 1 (see Figure 3).

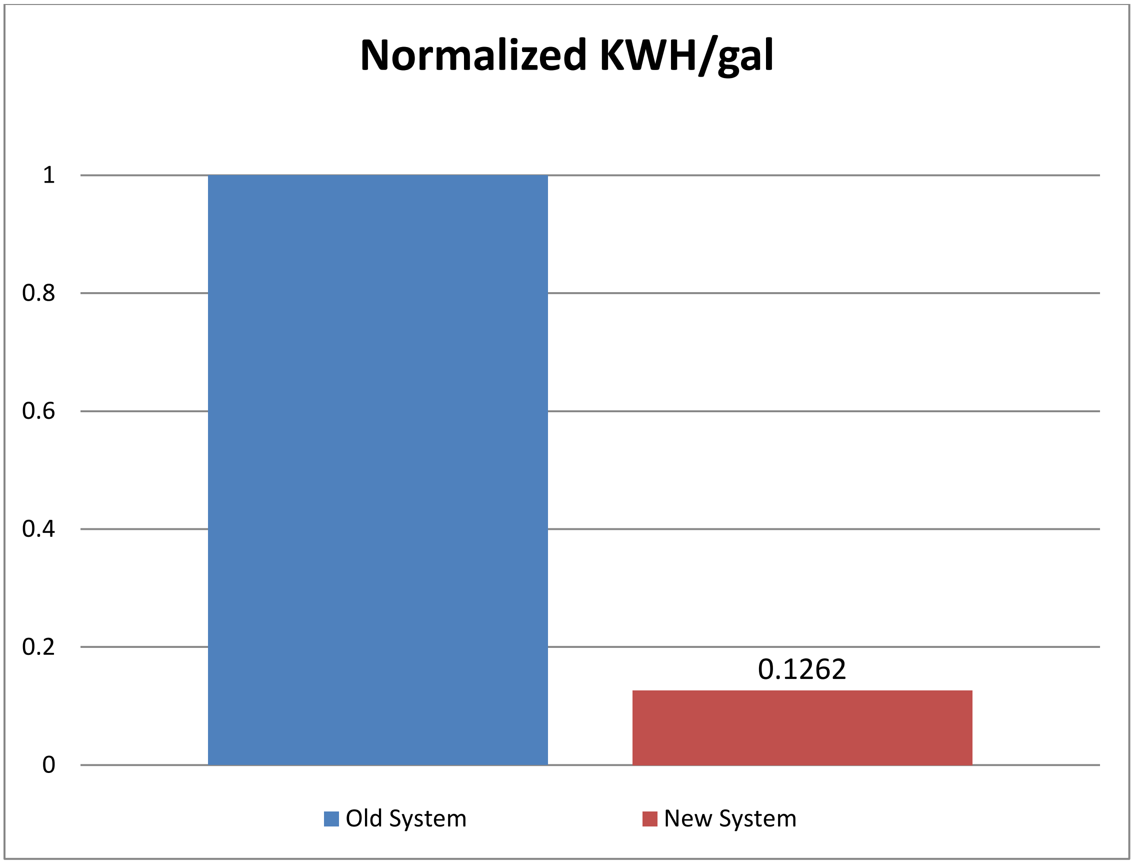


Figure 3: Comparison of Energy Use/Gallon for New System (Tristar) vs. LAP System

Based on the evaluation at PeroxyChem, the Tristar system required approximately 12.6% of the energy used by the older LAP system. For an electricity billing rate of $0.10/KWh, a potential savings of $11.10 in electricity costs can be achieved for every 1000 gallons filtered.

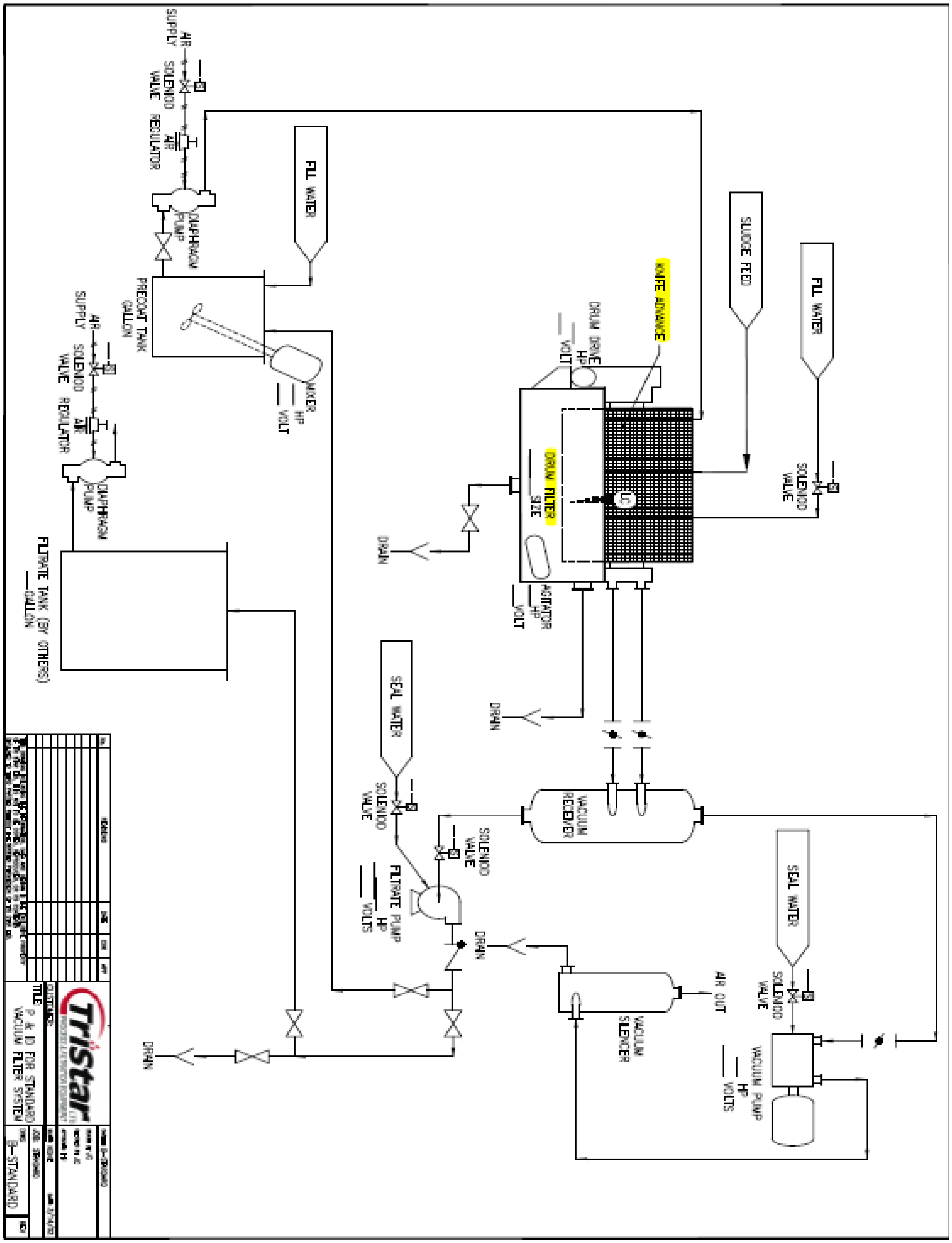
4. Conclusions

The goal of this project was to evaluate product claims regarding improved energy use and separation efficiency for a remanufactured rotary vacuum filtration system that utilizes the EDG-trac Knife Advance System. The installation of a system remanufactured by Tristar at PeroxyChem's facility in Tonawanda, NY facilitated the direct comparison of this system with an operating rotary vacuum drum filtration system. Two batch filtration tests were run for each system (older system and Tristar's remanufactured system) and performance compared. The most significant differences observed were that the Tristar system: 1) had a higher throughput, i.e. filtered the water at a much higher flow rate (7 times faster on average) and 2) consumed

12.6% of the energy used in the old system, on a per gallon filtered basis. The increase in throughput was directly attributed to the effectiveness of the knife advance system. The difference in energy requirements was, therefore, also linked to the performance of the knife advance system. The increase in processing times reduced the energy demand per batch by the vacuum pump, which was the largest energy consumer. Effluent quality showed little difference between the removal efficiency of the two systems (TSS ranging from 100 to 200 mg/l). The water content in the sludge cake produced by the Tristar system was slightly higher; the difference in sludge water content was attributed to the speed of drum rotation which can be adjusted to create drier sludge.

New York State Pollution Prevention Institute (NYSP2I)

Appendix 1: P&ID for Tristar EDG-trac System



Appendix 2: Data Log Sheet for Work Peformed at Peroxychem

PeroxyChem Data Log Sheet

DATE	ENERGY MEASUREMENT	AMOUNT FILTERED	TOTAL PRECOAT ADDED	WATER CONTENT	TOTAL SOLIDS DISPOSED	TOTAL SUSPENDED SOLIDS IN FILTRATE
Old LAP Filter Still in Operation						
4/24/2014	Meter hooked up on Filter Drum Drive at ~12:30PM			Sampled at 1PM		Sampled at 1PM
4/28/2014			Added 1/2 bag of filter aid for new precoat (25 lbs/bag)	Sampled at 3:30PM		Sampled at 3:30PM
4/29/2014	Meter hooked up on Filter Agitator Drive at ~10:30AM	Estimated 27.9% filtered from Backwash Tank (Assume 100% = 2,300 gal)		Sampled at 1:30PM	78 lbs solids disposed -12.5 lbs precoat = 65.5 lbs solids removed	Sampled at 1:30PM
4/30/2014	Meter hooked up on Vacuum Pump Drive at ~10AM		Added 1 bag of filter aid for new precoat (25 lbs/bag)	Sampled at 1:00PM		Sampled at 1:00PM
5/1/2014				Sampled at 11:15AM		Sampled at 11:15AM
5/2/2014				Sampled at 9:45AM		Sampled at 9:45AM
5/3/2014		Estimated 70.2% filtered from Backwash Tank (Assume 100% = 2,300 gal)			196 lbs solids disposed -25 lbs precoat = 171 lbs solids removed	
New Tristar Filter Installed between 5/5/14 and 5/9/14						
5/9/2014	Meter hooked up on Filtrate Pump Drive					
5/10/2014			Applied precoat to new filter, and tested operation.			
5/19/2014	Meter hooked up on new filter power supply (includes agitator, drum, and knife advance motors) at ~9:30AM	Couldn't establish consistent flow through filtrate pump, cut off filter cake and shutdown for maintenance repair.	Added 1 bag of filter aid for new precoat (25 lbs/bag) - NOTE: Filter cake fell off and was reapplied			
5/22/2014			Added 1 bag of filter aid for new precoat (25 lbs/bag) - NOTE: Filter cake fell off and was reapplied	Sampled at 1:30PM		Sampled at 1:30PM
5/23/2014		Estimated 138.9% filtered from Backwash Tank (Assume 100% = 2,300 gal)		Sampled at 7:30AM		Sampled at 7:30AM
6/2/2014			Added 1 bag of filter aid for new precoat (25 lbs/bag)	Sampled at 11:30AM Sampled at 4:00PM		Sampled at 11:30AM Sampled at 4:00PM
6/3/2014		Estimated 130.2% filtered from Backwash Tank			369 lbs solids disposed -25 lbs precoat = 344 lbs solids removed	
6/4/2014	Meter removed					

Appendix 3: Energy Measurements

		Old System (LAP)		New System (Tristar)	
		Batch 1	Batch 2	Batch 3	Batch 4
		4/28/14 09:00:00	4/30/14 10:45:00	5/22/14 10:50:00	6/02/14 11:00:00
		4/29/14 20:45:00	5/03/14 08:55:00	5/23/14 09:40:00	6/03/14 01:45:00
Time (H)	(Data from Table 1)	27.67	59.83	21.75	13.75
Volume (gal)		676.04	1600.65	3168.20	2976.05
Filter Drum Drive	KWH/gal	0.0043	0.0039	(Example calculation described in report)	
Filter Agitator Drive	KWH/gal	0.0196	0.0179		
Vacuum Pump Drive	KWH/gal	0.0864	0.0789	0.0145	0.0098
Filtrate Pump Drive	KWH/gal	0.0224	0.0205	0.0038	0.0025
New Filter	KWH/gal			0.0009	0.0006
Old System					
Per Batch	KWH/gal	0.1327	0.1211		
Average	KWH/gal		0.1269		
New System					
Per Batch	KWH/gal			0.0191	0.0129
Average	KWH/gal				0.0160
Normalization					
Old System		1	(Depicted in Figure 2 in report)		
New System		0.126180157			