Small-Scale
Paper Fiber Recovery

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FINAL REPORT

Prepared for

Recycling Technology Assistance Partnership (ReTAP)
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a division of the Pacific Northwest Economic Region (PNWER)
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SMALL-SCALE PAPER FIBER RECOVERY

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CONTENTS

EXECUTIVE SUMMARY

The lack of affordable, efficient, small-scale technologies for recovery of high-value, low-volume fiber, such as from poly-coated bleached paperboard, poses a significant technological barrier to their recycling. This report details the evaluation of a small-scale system for fiber recovery from milk carton/drink boxes (MCDBs). Pulp characteristics, effluent characteristics, and operating costs were monitored during the system's trial.

Typically, only large-scale paper producers/recyclers are able to sustain the high capital expenditures and low return on investment that are characteristic of most fiber recovery operations. Regenex L.L.C. (a spin-off company of Pellerin Milnor Corporation, a leading manufacturer of commercial laundry equipment) has developed a modular fiber recovery system that is a variation of an established Pellerin Milnor product line known as the continuous batch Tunnel Washer system. Due to the unique material transfer methods of the Tunnel Washer system, several process functions are combined in a single piece of equipment. The new technology also allows reasonable return on investment for value-added processing of MCDBs on a scale significantly smaller than conventional paper mill technology allows (e.g., on the order of 3 bone-dry-tons/day versus 300 bone-dry-tons/day). The modular system is characterized by both low capital cost and low operating expenses, thus making small-scale fiber recovery operations feasible.

Prototype Testing and Evaluation

The prototype system consisted of one seven-module continuous batch Tunnel Washer system. Monitored functions included loading, pulping, separating, reject handling, screening, washing/thickening, clarification of liquid streams, and overall system fluid flow. Post-consumer MCDB material from the Louisiana area was the feedstock for this trial.

Pulp Quality

Selected pulp characteristics were evaluated, including optical properties (brightness, dirt count, debris) and strength properties (freeness, burst index, tear index, tensile strength). These properties were compared to typical deink pulp specifications and historical MCDB recovered pulp.

Effluents

Effluent streams before and after clarification were evaluated for the following characteristics: Biological Oxygen Demand, Silica, Total Suspended Solids, Total Dissolved Solids, Chlorine, Total Metals

CONCLUSIONS

The following is a summary of the conclusions based on the results of the tests conducted on the continuous batch Tunnel Washer system offered by Pellerin Milnor's RE GENEX Division.

- System yield was 63.8% BDT to BDT for post-consumer MCDB.
- For variable costs to be comparable to a state of the art, optimum sized, market deink pulp mill, the yield on milk carton must be about 73% BDT to BDT. This will need to be re-evaluated when quality targets have been achieved.
- Performance/strength properties, with the exception of freeness, did not meet typical deink pulp specifications for fine paper applications, but did fall within typical historical parameters for post-consumer MCDB pulp.
- Strength properties of the post-consumer MCDB may have been influenced by the advanced state of bio-decomposition of the feed stock, which was over 6 months old.
- Loss of fines at the three sequential pulp sampling stages across the system resulted in a progressive reduction in all strength properties except tear index. Freeness increase across system also supports this theory.
- Fiber and poly-coat percentages in the composite system reject stream were 35% and *65%* respectively, by dry weight.
- The only optical property to exceed typical deink pulp specifications for printing and writing and tissue grades was brightness.
- When Weyerhaeuser tested the Clarifier Feed Sample, it's pH registered 12.0, which was the same as the target pH.
- The TSS particles, in the system effluent stream, are easily floated and removed at the clarifier, visual inspection found a large portion of the TSS to be fiber.
- BOD values reported are questionable due to wide variability of values obtained during testing.
- Total Metals Analysis values show a large decrease from clarifier feed to effluent.
- No concerns were raised about the levels of metals present in the sludge from this trial.

RECOMMENDATIONS

- Need further testing/study to reduce dirt count and increase strength properties.

- Need to increase yield to a minimum of 73% BDT to BDT in order for the system to be economically viable.
- Screw press should be sized for the typical load size of 80 to 100 pounds (direct feed of rejects to a screw press for dewatering is currently dependent on running loads of (60 pounds).

Analysis, and pH. Effluent characteristics of the MCDB system were comparable to those for a typical mixed office waste (MOW) deink system. The total metal content values from both the system effluent and the system sludge were within acceptable limits.

Operating Costs

Baseline data includes stream flow rates, operating temperatures and times, and chemical dosages. Operating costs are extrapolated to compare a Tunnel Washer system processing MCDBs with a state-of-the-art deink system processing MOW. References to operating costs include only variable cost and labor. Semi-variable costs (operating and maintenance supplies) and fixed costs (depreciation, taxes, salaried labor) are not included. The MCDB system is penalized for labor due to lower production capacity; however, the system is more cost effective than a state-of-the-art deink system for chemicals and energy. Effluent treatment and residual disposal are comparable between the two systems. The test system yield was 63.8% BDT to BDT (bone dry ton of feed stock to bone dry ton of pulp product) for post-consumer MCDB. For variable costs to be comparable to a state of the art, optimum sized, market deink pulp mill, the yield on milk carton would need to be approximately 73% BDT to BDT.

Future Development

Further development work by Regenex L.L.C. has resulted in significant optical property improvements: a dirt count of 10 PPM and debris level of 0.03%. Additional testing must be performed to demonstrate improved strength properties. *(Strength properties, with the exception offreeness, did not meet typical deink pulp specifications for fine printing/writing grade paper, but did fall within typical historical parameters for post-consumer MCDB pulp.)* Work is currently underway to process other waste paper feedstocks, in addition to MCDBs.

Equipment Availability

Regenex **L. L. C.** markets modular fiber recovery systems that can be sized to produce from **3 to** 250 tons per day. For more information on current product offerings, contact: Dan Mulligan, Regenex L.L.C.; P.O. Box 400, Kenner, LA *(504)* 467-9591; or (206) 869-8648 (in Washington State).

Acknowledgments

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gratefully acknowledged.

1.0 BACKGROUND

Pellerin Milnor (PM) is located in Kenner, Louisiana, just outside of New Orleans. They engineer, manufacture, install, and service industrial size laundry equipment. It has been proposed that with a few modifications, the continuous batch Tunnel Washer system offered by Pellerin Milnor’s newly established RE GENEX Division can be used to recycle milk carton/drink boxes (MCDB’ s). Initial trials for this application were conducted in September of 1994. Based on the data generated in that trial, modifications were made to the Tunnel Washer system to prepare for additional testing.

The Clean Washington Center is engaged in investigating promising recycling technologies for various types of recovered paper, including poly-coated bleached paperboard. The lack of affordable, efficient, small-scale technologies to recover high-value, lower volume fiber, such as poly-coated bleached paperboard led the Clean Washington Center to provide funds for the evaluation of PM's Tunnel Washer system. Weyerhaeuser provided the necessary expertise and resources to evaluate the system prototype for operating costs, effluent characteristics and pulp characteristics using MCDB feed stock.

During discussions of the data generated from the September trials, Weyerhaeuser and PM decided to focus follow-up testing on pulp quality from various stages of the PM system, and on identifying any additional processing which would be needed. Rather than the two four-module systems used in the September trial (one to simulate pulping and separating, one to simulate cleaning), this evaluation used one seven-module continuous batch Tunnel Washer system to simulate pulping and separating. Post consumer MCDB material, collected from areas around Louisiana, were used in this trial. Five 100 pound batches were processed to assure that the system would reach a steady state.

2.0 TEST PROCEDURE

This section describes the work completed by Weyerhaeuser and PM to test the Tunnel Washer system for its potential to process MCDB's. Section 2.1, Process Description, provides a description of the Tunnel Washer system and the feedstock processing methodology. A description of the tests and sampling methodology used to evaluated the pulp and effluent quality of the MCDB feedstock is provided in section 2.2, Sampling Description.

2.1 PROCESS DESCRIPTION

This section describes the batch system used to process MCDB's. Rather than the two four-module systems used in the September trial (one to simulate pulping and separating, one to simulate cleaning), this evaluation used one seven-module continuous batch Tunnel Washer system to simulate pulping and separating. The MCDB processing system includes the following component parts: loading; pulping and separating; rejects handling; screening; washing/thickening; clarification of liquid streams; and flow rates. Post consumer MCDB material, collected from areas around Louisiana, were used in this trial. Five 100 pound batches were processed to assure that the system would reach a steady state. Figure 1, in Appendix A shows the process flow diagram for the system under test.

2.1.1 Loading

Five 100 pound batches of Milk Carton (MC) material were weighed and placed in plastic bags. A bag of MC was dumped onto a scoop that was hydraulically raised to deliver the material to module 1. In a commercial installation, bales of MC material would be broken and dumped onto a weight sensitive conveyor that would carry the material to the first module. The conveyor is sensitive to +/-10 pounds.

2.1.2 Pulping and Separating

A seven-module continuous batch tunnel washer system was used to achieve pulping and separating (Figure 1). The entire system is enclosed, therefore no sampling can take place until after these two operations have been completed. As can be seen in Table 1, the first four modules have baskets with ribs to provide additional mechanical action to facilitate poly/fiber separation. A change from 0.25 inch holes to 0.03 inch screen is made between modules 1 and 2 to prevent loss of fiber that has already broken down in module 1. The change from 0.03 inch screen to 0.25 inch holes from module four to modules five, six, and seven insures removal of all pulp that has been separated from the poly-coating.

Table 1. Mechanical Configuration		
Module	**Drum Configuration**	**Screen or Basket Hole Size (in.)**
1	Ribs and holes	0.25
2	Ribs and Screen	0.03
3	Ribs and Screen	0.03
4	Ribs and Screen	0 03
5	Holes	0.25
6	Holes	0.25
7	Holes	0.25

Pulping pH is controlled by the addition of sodium hydroxide (caustic), target pH which is monitored at each of the four pulping modules was 12. The pH measured, on site, at the clarifier, was 10.7. This pH value was less than the target of 12 because the drain trough effluent is diluted by reject water, very dirty water from module one (R), and what normally would be counter-flow water from module two to module one (W), (in this trial this water went to the trough). By the time this water gets to the clarifier, it is thoroughly mixed and diluted, resulting in a lower pH. Fresh chemicals (bleach H2O2 and caustic) are added to modules 1-4 only, any chemicals associated with modules 5-7 occurs due to the chemical residue in the clarified water recirculated to these modules. As seen in Table 2, pulping temperatures are higher than separation temperatures. The system is capable of maintaining different temperatures and chemical compositions in each module. As the number of modules in the system increases the residence time in each module decreases, keeping the overall time for pulping and separating constant.

Table 2: Pulping Parameters		
Module	**Temperature F**	**Residence Time (min.)**
1	200	22
2	200	22
3	200	22
4	200	22
5	125	22
6	125	22
7	125	22

Modules 1-4 are pre-dosed with bleach (H2O2) and caustic upon start-up of the equipment. During operation, each of these pulping modules that contains material receives and additional half pound of H2O2 (1 pound of caustic in module 1, 3/4 pound in module 2, 3, and 4) every time a load is transferred forward. By the time each 100 pounds of MC enters Module 5, it has received a total of 2 pounds of H2O2 and 3.25 pounds of caustic. The amount of caustic addition will drop off considerably the longer the system is run due to re-circulation of chemically rich water from the clarifier.

2.1.3 Rejects Handling

Rejects from the pulping/separating system dump out of Module 7, at location (M) into a perforated dumpster, each time a load is transferred. Due to the limitations of the existing screw press used in the system under test, if loads of material (60 pounds are run, rejects from the system and the vibrating screen can be fed directly to a screw press and dewatered to 25-30% consistency. For the 100 pound loads run in this trial, rejects were removed from the perforated dumpster by hand and fed to the screw press. This restriction could be eliminated by the installation of a larger capacity screw press. Screw press effluent (V) flows into the effluent trough underneath the pulping/separating system and is pumped to the clarifier. Screw press solids (poly and fiber) are collected in a dumpster for disposal at a landfill (S).

2.1.4 Screening

Pulp flows through the 0.25 inch holes of the separation section (Modules 5-7) and is pumped onto a vibrating screen at 0.540 % consistency, at location (A). The vibrating screen is equipped with 0.059 inch slits for removal of remaining poly-coat. Rejects move along the top of the vibrating screen and pile up in a trough at the end, at location (N), they then slide down a tube to combine with system rejects from Module 7.

2.1.5 Washing/Thickening

Pulp from the vibrating screen, at location (B), is fed to a side hill screen at 0.37 % consistency. As the pulp flows down the screen dirt is removed and the pulp is thickened to 6.20 % consistency. The finished pulp “product” accumulates, at location (C), in a trough at the bottom of the screen where it is diluted and pumped to a holding tank. Effluent from the screen, at location (F), flows to a concrete trough underneath the pulping/separating system where it mixes with the other system effluents before being pumped to the clarifier.

2.1.6 Clarification of Liquid Streams

System effluents are mixed in a trough, at location (F), underneath the 7 module system and then pumped to a Krofta clarifier at 53.89 gpm. Clarifier Filtrate is pumped, at location (J), from a tank adjacent to the clarifier to a tank adjacent to Module 1 where it is mixed with fresh make-up water. Clarifier sludge is deposited into a tank adjacent to the clarifier before being pumped to a dumpster, at location (L). A Cytec Chemicals representative was on hand to monitor chemical application, and a Krofta representative monitored the clarifier operation. A copy of the report and data on the polymer usage are included in Appendix 3.

2.1.7 Flow Rates

The letters in Table 3 correspond with the process flow diagram in Figure 1, and Appendix 4. Fresh water enters the system at K, all other water used by the system is clarified water from the Krofta. Water loss from the system occurs in the clarified sludge, final pulp product, and screw press rejects.

Table 3: Process Diagram Location

Letter (See Figure 1)	**Flow Rate (gpm)**	**Description**	
	A	55.00	Separation module accepts / vibrating screen feed (pulp+water)
	B	54.98	Vibrating screen accepts / side hill feed (pulp + water)
	C	6.83	Side hill screen accepts (pulp + water)
	F	48.15	Side hill screen effluent - to clarifier
	G	3.00	Pulping section input - clarified water
	H	1.25	Flushes loads into module 1 - clarified water
	I	53.89	Effluent mixture from trough - clarifier feed
	J	51.20	Clarifier Filtrate - to tank for system water supply
	K	8.05	Fresh make-up water - mixed with clarifier filtrate to supply system

L	2.69	Sludge from clarifier - to landfill
N	0.02	Pulping / Separating Rejects Poly, water, and some fiber - to screw press for dewatering
M	1.50	Vibrating Screen Rejects Poly, water, and some fiber - to screw press for dewatering
S	0.01	Dewatered rejects - to landfill
R	1.00	Very dirty water from module 1
W	3.00	Usually counter-flow water, fiber - went to clarifier in this trial
P	55.00	Clarified water back to separating and pulping sections
V	1.49	Screw press effluent - to clarifier

2.2 SAMPLING DESCRIPTION

Samples were taken after each of the three stages of the PM system (A, B, and C) to evaluate the improvement in pulp quality after each stage, and to determine the necessity for supplementing the PM system with conventional cleaners or screens. Small samples were taken at each stage, every 20 minutes, and deposited into a 5 gallon bucket to generate composite samples.

The Vibrating Screen Feed sample represents the accepts from the 7 module pulping/separating system. Pulp was collected into a cup, then emptied into a bucket, as it flowed onto the vibrating screen (A). Vibrating Screen Accepts/Side Hill Feed samples were taken at the side hill before the pulp was deposited onto the top of the side hill (B). Side Hill Accepts were sampled by scooping the pulp off of the bottom of the side hill screen before they fell into the trough. This sample represents the "final product" (C).

Clarifier Feed (I), Filtrate (J), and Sludge (L) samples were also composite samples. Clarifier feed samples were taken from the trough underneath the 7 module system. Clarifier filtrate samples were taken from the pipe coming out of the clarifier. Sludge samples were taken from the tank adjacent to the clarifier.

Strength testing includes: TAPPI brightness, basis weight, caliper, density, burst index, tear index, tensile index, tensile energy absorption, elongation, and breaking length (Table 4). Environmental testing on the sludge consisted of a total metals analysis. Clarifier Feed and Filtrate were tested for BOD, Silica, Total Suspended Solids, Total Dissolved Solids, Chlorine, Total Metals Analysis, and pH.

Table 4: Sampling and Testing

Sample ID	Consistency	Freeness	Dirt Count	Debris	*Strength	Environmental
Vibrating Screen Feed	Yes	Yes	Yes	Yes	Yes	No
Vibrating Creen Accepts	Yes	Yes	Yes	Yes	Yes	No
Side Hill Accepts	Yes	Yes	Yes	Yes	Yes	No
Clarifier Feed	Yes	No	No	No	No	Yes
Flarifier Filtrate	Yes	No	No	No	No	Yes
Sludge	Yes	No	No	No	No	Yes

Appendix C contains a copy of the TAPPI test methods.

3.0 TEST RESULTS

This section describes the results of the MCDB feedstock sampling for each of the parameters described in Section 2.2. Test results were compared against typical specifications for both pulp and effluent quality. Specifications for pulp quality include optical properties (i.e., brightness, dirt count), and performance/strength properties (i.e., burst index, tensile, elongation, tensile index, TEA, breaking length, tear index, and freeness).

These results will help determine the effectiveness of the Tunnel Washer system in processing MCDB's for use as pulp feedstock. Specifications for effluent quality are derived from local water quality control regulations and criteria set by state and local governments. These parameters include pH, TDS, total suspended solids, BOD (biological oxygen demand), and total metals.

This section also provides estimated operating costs associated with a commercial scale system for processing MCDB's using this technology.

3.1 PULP QUALITY

Table 5: Testing Results and Comparison to Typical Deink Pulp Specifications						
				Typical	**Values**	
Test Performed	*Separation Module Accepts Vibrating Screen* Feed (A)	*Vibrating Screen Accepts (B)*	*Side Hill Accepts (C)*	*MCDB Historical Data*	*Med. Grade Tissue*	*Printing/ Writing Grade*
			Optical Properties			
Brightness (TAPPI)	81.77	82.95	84.6	65-80	75	80-84
Dirt Count (PPM)	1757.35	1229.43	261.62	5-1600	<30	<10
Debris (%)	0.784	0.05	0.1		<0.15	<0.1
			Performance Strength Properties			
Freeness (CSF, ml.)	522	546	673	570-650	500	500
Consistency (%)	0.54	0.37	6.2			
Basis weight (g/m2)	63.4	64.95	65.17			
Caliper (mm)	0.115	0.12058	0.12484			
Density (kg/m3)	551.465	538.707	522.12			
Bulk (cm3/kg)	1.81387	1.8565	1.9156			
Burst Index (kN/g)	1.1092	1.0297	0.86756	0.6-2.2		1.42-2.51
Tear Index (mN*m2/g)	60.321	6.1299	6.2897	4-10		7.23-10.06
Tensile (kN/m)	1.452	1.431	1.304	0.6 - 2.2		1.4 - 2.52
Tensile Index (Nm/g)	22.91	22.03	20.01			31.8-46
Elongation (5)	2.17	2.119	1.876			2.39-4.38
TEA (J/m2)	26.08	25.16	20.61			33.5-88
Breaking Length (km)	2.336	2.246	2.04	1.1-3.5		3.24-4.69

3.1.1 Optical Properties

Dirt and debris removal across the system resulted in an increase in brightness. The small increase in debris across the side hill screen (from 0.05 to 0.1%) is insignificant. All of the samples exceeded the brightness specifications for typical deink pulp for use in printing and writing grade papers. Dirt count numbers are too high to meet specifications for any of the above deink pulps. Typical debris specifications were met by the vibrating screen and side hill accepts samples. MCDB historical data dirt count and brightness ranges are broad because these qualities are highly dependent on how the MCDB material is collected and processed.

3.1.2 Performance/Strength Properties

Several solutions have been proposed to increase the consistency of the final product for shipment. Pellerin Milnor has proposed using a press currently used in the laundry industry that can dewater to 50% consistency. Re-pulping may be a problem at this high consistency. Another solution, proposed by Weyerhaeuser, is to use a screw press to generate “noodle pulp” at about 25-30% consistency.

Burst Index, Tensile, Elongation, Tensile Index, TEA, and Breaking Length saw decreases of 21.8%, 10.2%, 13.5%, 12.7%, 21%, and 12.7% respectively, while Tear Index increased 4.1%, across the entire system. These results indicate the loss of short fibers “fines” across the system, and since fines are the “bridges” that promote fiber-to-fiber bonding, strength properties that are more dependent on this type of bonding suffer. A Kajaani test of average fiber length would be needed to confirm this theory.

The freeness increase from 522 to 673 ml. also supports the loss of fines theory. The milliliters of fluid collected from the fiber mat contained in the freeness test apparatus increases as the amount of short fibers in that mat decreases. The short fibers fill in the “holes” in the mat and impede drainage.

Freeness was the only performance/strength property that met the typical deink pulp specifications.

Rejects from module 7 were dried to determine the amount of oven dry (OD) fiber and poly-coat. The rejects consisted of 35% fiber and 65% poly-coat.

3.2 EFFLUENT CHARACTERISTICS

A copy of the Clarifier Feed, Clarifier Effluent, and Sludge analysis can be found in Appendix 3. Values that were well above the quantitation limit are summarized in Tables 7 and 8. The quantitation limit represents the lowest detection level possible. As test values approach the quantitation limit, their accuracy becomes less reliable.

The MCDB Clarifier Feed sample in Table 6 was taken from the effluent trough and registered a pH of 12, which was the target pH for this trial. As mentioned earlier, the on-site pH of this sample was 10.7 due to dilution of the sample. The high TDS are probably due to the residual pulping chemicals. Total Suspended Solids represents the fiber, poly, etc. that make it through the system. The large reduction in TSS from clarifier feed to effluent shows that these particles are easily floated to the top of the clarifier and removed. Visual inspection revealed that a large portion of the TSS are fibers. The BOD samples tested had a large amount of variability, the accuracy of the values in Table 6 are therefore questionable. Due to the absence of ground wood in the MCDB material, no Sodium Silicate was needed in the pulper, resulting in lower silica values than the MOW samples.

Table 6: Effluent Characteristics - Clarifier Feed and Effluent Samples

Test	Unit	MCDB Clarifier Feed	MCDB Clarifier Effluent	MOW Clarifier Feed (For Comparison
pH	mg/L	12.0	11.3	8.2
TDS	mg/L	1420	940	460
TSS	mg/L	870	10	3800
BOD	mg/L	230	170	890
Cl	mg/L	46	42	0.3
Si as SiO2	mg/L	1.43	1.17	275

The increase in calcium from the clarifier feed to effluent is questionable, these samples may have been switched during testing (Table 7). There is a significant drop all of the other metals from feed to effluent. The high amount of Sodium (Na) in the clarifier feed and effluent samples represents the sodium portion of the Sodium Hydroxide (Caustic) added to the pulping section. According to the people testing these samples, none of these metals are at levels that raise concerns. No data was available from MOW for comparison to the clarifier feed and effluent values in Table 7. The units used in Table 7 are micro grams per liter.

Table 7: Total Metals Analysis - Clarifier Feed and Effluent Samples				
Element	**Unit**	**MCDB Clarifier Feed**	**MCDB Clarifier Effluent**	**Quantitation Limit**
Al	ug/L	2000	900	200
Ca	ug/L	12900	16100	500
Fe	ug/L	1100	<100	100
Mg	ug/L	2000	600	100
Mn	ug/L	30	<10	10
Mo	ug/L	50	30	10
Na	ug/L	473000	273000	1000
P	ug/L	900	400	200
Zn	ug/L	120	<20	20

Sludge sample metals that fell above the quantitation limit are summarized in Table 8. MOW sludge values are shown for comparison. None of the values reported in Table 8 are high enough to be of concern.

Table 8: Sludge Samples				
Element	**Unit**	**MCDB Sludge**	**Quantitation Limit**	**MOW Sludge (For Comparison)**
Cr	mg/kg	4	1	0.3 - 0.6
Cu	mg/kg	16	2	1.1 - 2.4
Pb	mg/kg	2.8	0.3	0.3 - 0.7
Zn	mg/kg	86	2	8.6 - 54.2

3.3 OPERATING COSTS

Operating costs associated with a commercial scale system have been estimated using data from Pellerin Milnor, the most recent pilot plant trial, and Weyerhaeuser Paper Company engineering. Details on the units of consumption, and unit cost are included in Appendix 1.

It is important to note that the operating costs described in this section include only variable cost and labor. Semi-variable costs (such as operating and maintenance supplies), and fixed costs (such as depreciation, taxes, salaried labor) are not included.

The variable operating costs can be used on a comparable basis, and are a useful tool to evaluate the impact of a given variable, such as yield or raw material cost, on the variable cost associated with producing a ton of finished product. However, any economic analysis of the investment such as net present value (NPV) or return on investment (ROI) would have to include annualized semi variable and fixed costs.

Three variables have been evaluated for milk carton: yield, raw material cost, and plant capacity. A brief discussion of each follows.

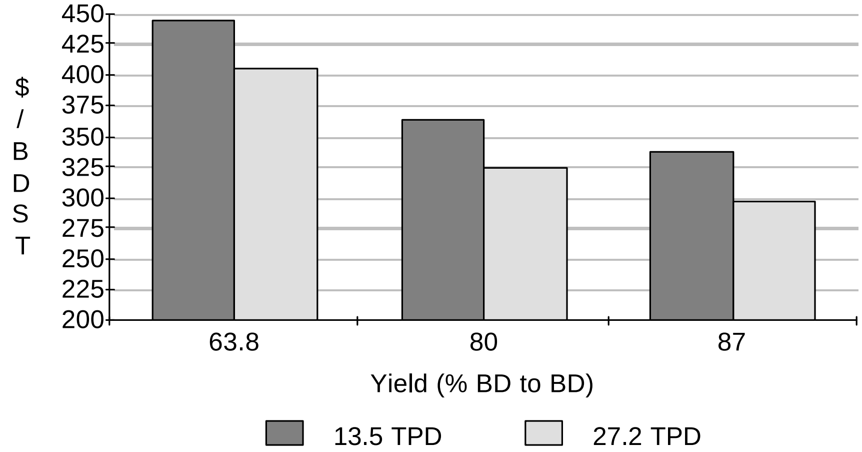
Yield from the pilot plant trial was calculated at 63.8% (bone dry feed stock to bone dry pulp product) for milk carton. The impact of yield on operating cost was determined using 63.8%, 80% (average yield) and 87% (theoretical maximum) for milk carton.

Raw Material - In all cases it was assumed that freight would average $25/SWT (scale weight ton). Raw material costs of $120/SWT and $150/SWT were used in the operating cost model. Actual consistency of 88.6% for milk carton was used, from the pilot plant trial, to convert from SWT to BDT (bone dry ton).

Plant Capacity - All operating costs have been equated to a $/BDST (bone dry short ton) of product out. Two plant capacities were used based on data supplied by Pellerin Milnor (6 January 1995) for a 24 and 48 module system. For the purpose of the operating cost model it was assumed that the 24 module system would average 13.5 BDSTPD on milk carton. The 48 module system capacity is 27.5 BDSTPD (bone dry short ton per day) on milk carton.

As can be seen in Figure 2, the yield has a significant impact on the operating costs associated with converting milk cartons. The plant capacity also impacts the operating cost as it is assumed that the labor would remain constant with both 24 modules and 48 modules. All operating cost data summarized in Figure 2 is based on milk carton stock at a price of $120/SWT.

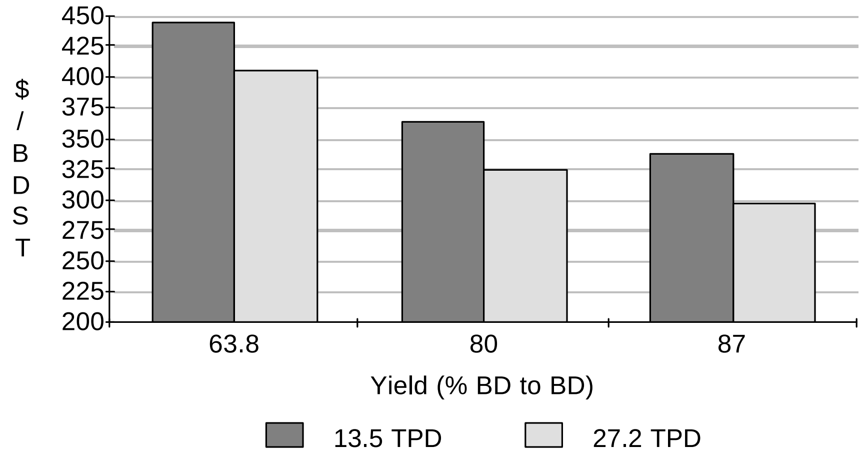
Figure 2: Impact of Yield and Capacity on Operating Cost -$120/SWT MC



The operating cost is reduced by about $37/BDST when the system capacity is increased from 13.5 TPD to 27.2 TPD.

Figure 3 summarizes the same yield and capacity assumptions for milk carton, but assumes that the value of the milk carton is $150/SWT.

Figure 3: Impact of Yield and Capacity on Operating Cost -$150/SWT MC



The $30/SWT increase in raw material cost equates to an increased operating cost of approximately $53/BDST, $42/BDST, and $39/BDST for a yield of 63.8%, 80% and 87% respectively.

Summarized in Table 9 is the non-raw material, variable and non-salaried labor costs associated with the conversion of milk cartons using the ReGenex System and a state of the art deinking system processing mixed office waste (MOW).

Table 9: Cost Comparison Summary - $/ton

	Milk Cartons 24 Modules (13.5 TPD)	MOW 1 line (270 TPD)
Labor (1)	73.42	14.06
Chemicals(2)	25.76	42.84
Energy(3)	1.21	27.56
Other(4)	14.25	16.53
Total	114.64	100.99

1) Labor rates held constant for both facilities. If union wages were paid at MOW facility, labor would increase by approximately $11/ton.

(2) Assumes cost/unit is the same at both facilities. In actuality because the usage (on a daily basis) would be so much lower, the MCDB chemical costs are artificially low.

(3) Energy cost/unit assumes steam and energy are available from an industrial site, such as a paper mill. If the facility is required to purchase electricity and steam from a municipality the energy numbers may increase significantly.

(4) Other includes BOD, TSS, and effluent flow as well as residual solids disposal and fresh water usage. Again, cost/unit assumes the recycle facility is adjacent to a paper mill.

The milk carton system is penalized for labor due to the limited production. The ReGenex system is more cost effective than a state of the art deink system for chemicals and energy. Effluent treatment and residual disposal is comparable between the two systems.

The overall conversion costs are about $14/BDT lower on MOW. Once again, fixed costs and semi-variable costs, excluding hourly labor, are not included.

Raw material costs are highly volatile, especially for MOW. Assuming the following trend pricing and yields, we can determine the yield required from milk cartons to be comparable to a state of the art market pulp mill.

Milk Cartons *MOW*

Moisture (%)	11.4	10
Trend Price ($/SWT)*	150	150
Yield BDT to BDT	----	68
Yield SWT to BDT	----	61.2

* This is a long term price, today's price is actually higher

Using these assumptions, the cost to convert MOW is summarized in Table 10 compared to the cost equivalent yield for milk carton.

Table 10: Conversion Costs

	MOW $/BDST	**Milk Cartons $/BDST**
Labor	14.06	73.46
Chemicals	42.84	27.76
Energy	27.56	1.21
Other	16.53	14.25
Raw Materials	245	231.45
Total	346.09	346.09

To achieve a raw material cost of $231.45/BDST of finished product, the milk carton facility must have a yield of approximately 73% BDT to BDT.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This section presents a summary of conclusions based on the results of the tests conducted on the Tunnel Washer system.

- System yield was 63.8% BDT to BDT for post-consumer MCDB.

- For variable costs to be comparable to a state of the art, optimum sized, market deink pulp mill, the yield on milk carton must be about 73% BDT to BDT. This will need to be re-evaluated when quality targets have been achieved.

- Performance/strength properties, with the exception of freeness, did not meet typical deink pulp specifications for fine paper applications, but did fall within typical historical parameters for post-consumer MCDB pulp.

- Strength properties of the post-consumer MCDB may have been influenced by the advanced state of bio-decomposition of the feed stock, which was over 6 months old.

- Loss of fines at the three sequential pulp sampling stages across the system resulted in a progressive reduction in all strength properties except tear index. Freeness increase across system also supports this theory.

- Fiber and poly-coat percentages in the composite system reject stream were 35% and 65% respectively, by dry weight.

- The only optical property to exceed typical deink pulp specifications for printing and writing and tissue grades was brightness.

- When Weyerhaeuser tested the Clarifier Feed Sample, it's pH registered 12.0, which was the same as the target pH.

- The TSS particles, in the system effluent stream, are easily floated and removed at the clarifier, visual inspection found a large portion of the TSS to be fiber.

- BOD values reported are questionable due to the wide variability of values obtained during testing.

- Total Metals Analysis values show a large decrease from clarifier feed to effluent.

- No concerns were raised about the levels of metals present in the sludge from this trial

RECOMMENDATIONS

- Need further testing/study to reduce dirt count and increase strength properties.

- Need to increase yield to a minimum of 73% BDT to BDT in order for the system to be economically viable.

- Screw press should be sized for the typical load size of 80 to 100 pounds (direct feed of rejects to a screw press for dewatering is currently dependent on running loads of (60 pounds).

5.0 ACKNOWLEDGMENTS

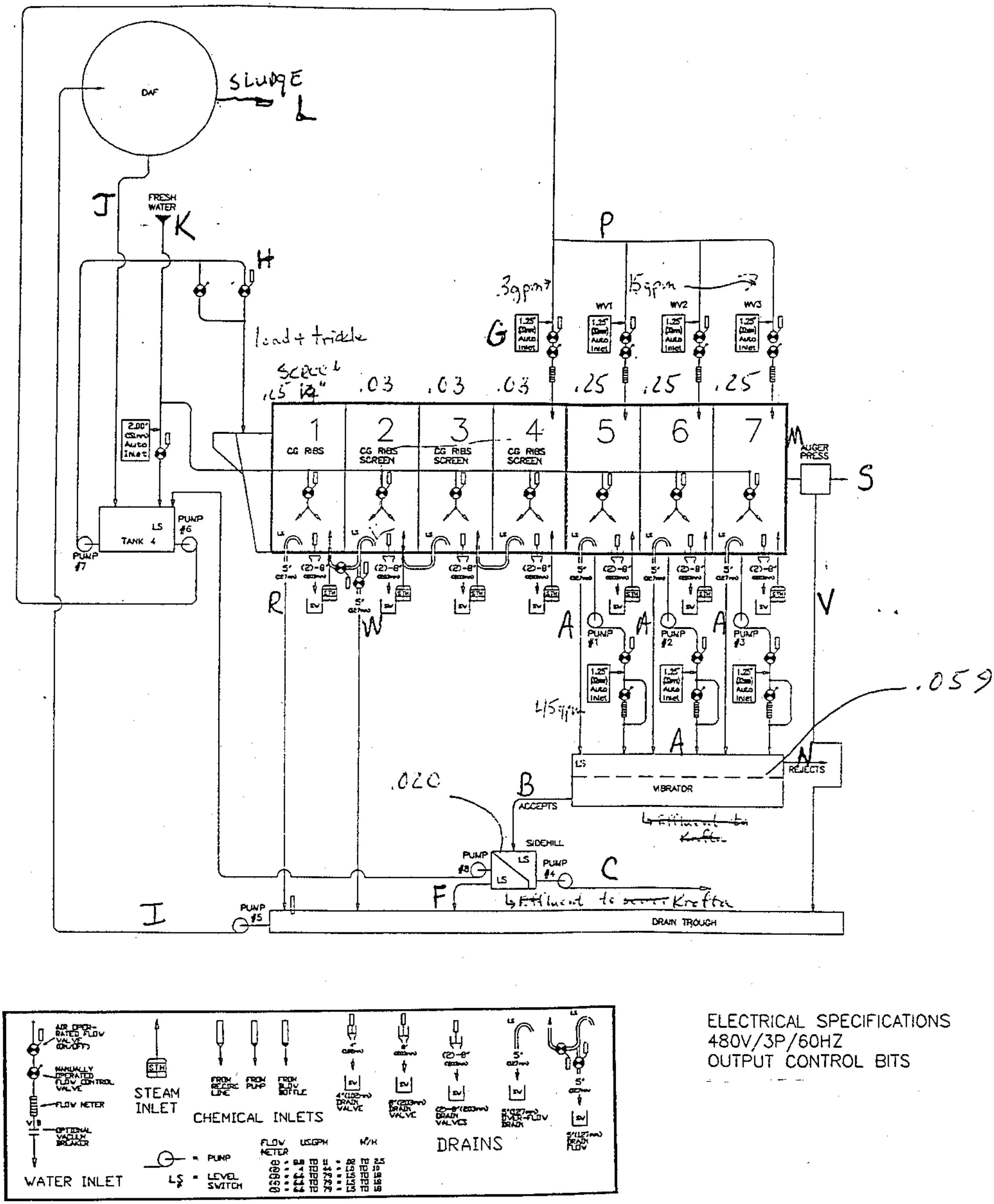
The following organizations contributed their time, effort, support and understanding during the conduct of this project:

1. Weyerhaeuser Corporation, Research and Development
2. Pellerin Milnor Corporation. (Regenex L.L.C.)

ReTAP is a joint venture of the Clean Washington Center, Washington State's lead agency for the market development of recycled materials, and the National Recycling Coalition, a 3,500 member nonprofit organization committed to maximizing the benefits of recycling. ReTAP is an affiliate of the national Manufacturing Extension Partnership (MEP), a program of the U.S. Commerce Department's National Institute of Standards and Technology. The MEP is a growing nationwide network of extension services to help smaller U.S. Manufacturers improve their performance and become more competitive. ReTAP is also sponsored by the U.S. Environmental Protection Agency and the American Plastics Council.

APPENDIX 1

PROCESS FLOW DIAGRAM



ELECTRICAL SPECIFICATIONS
480V/3P/60HZ
OUTPUT CONTROL BITS

Figure 1: Process Diagram

APPENDIX 2

EFFLUENT/SLUDGE TEST RESULTS & POLYMER APPLICATIONS

UPDATED 3/17

ANALYTICAL LABORATORY SERVICES REQUEST

Research and Development – Analysis and Testing

Request Number: 17445		
Title: PELLERIN MILNOR SLUDGE		
Number of Samples: 2	Project Number: 042-2040	Groups: 3
Date Received: 03/13/95	Date Desired: 04/03/95	Sample Disposition:
Submitted By: BECK, DARLENE	Location: WTC 2B19	Ph: 924-6112
Reviewed By: LANZA Mary Beth	Location: WTC 2F25	Ph: 924-6013/6188
Project Title: RECYCLE MATLS UTILIZATN	Project Leader: FRIBERG - WTC2C19	

Copy To:

Sample Description and History:

Group	Series	Test Description		
		Report Range	Report Basis	Lower Limit of Sensitivity

UPDATED

Sample Number	Series to Be Evaluated	Submitters Designation	Date Recd
43429	A	CUP SLUDGE 03/06/95	03/13/95
43430	A	MCDB SLUDGE 03/06/95	03/13/95

Reference: 16681

Results Approved: [signature]

Date: 4/3/95

Signature Applies To Attached Pages:

Record Book:

Page Numbers:
To:

WEYERHAEUSER COMPANY
ANALYTICAL LABORATORIES
ATOMIC SPECTROSCOPY
Tacoma, WA

Pellerin Milnor Sludge
SR 17445
Total Metals Analysis

Element	43429 Cup Sludge 3/6/95	43429D Duplicate	43430 MCDB Sludge 3/6/95	Quantitation Limit	Method Number
			(mg/kg, air dried basis)		
Ag	< 1	< 1	< 1	1	AM1-3050/6010
As	< 0.3	< 0.3	< 0.3	0.3	AM1-3050/200.9
Be	< 1	< 1	< 1	1	AM1-3050/6010
Cd	< 1	< 1	< 1	1	AM1-3050/6010
Cr	2	2	4	1	AM1-3050/6010
Cu	13	14	16	2	AM1-3050/6010
Hg	< 0.9	< 0.9	< 0.9	0.9	AM1-245.5
Ni	< 3	< 3	< 3	3	AM1-3050/6010
Pb	1.1	1.1	2.8	0.3	AM1-3050/200.9
Sb	< 5	< 5	< 5	5	AM1-3050/6010
Se	< 0.3	< 0.3	< 0.3	0.3	AM1-3050/200.9
Tl	< 0.3	< 0.3	< 0.3	0.3	AM1-3050/200.9
Zn	50	49	86	2	AM1-3050/6010
% Solids @ air dried	2.4	2.6	3.5		AM1-TS-CLP Modified
% Solids @ 105c	2.4	2.6	3.8		AM1-TS-CLP

Approved Julie Reimer

Report Date 4/3/95

WEYERHAEUSER COMPANY
ANALYTICAL LABORATORIES
ATOMIC SPECTROSCOPY
Tacoma, WA

Pellerin Milnor Sludge
SR 17445
Total Metals Analysis

Element	43429 Cup Sludge 03/06/95	43429D Duplicate	43430 MCDB Sludge 03/06/95	Quantitation Limit	Method Number
		(mg/kg, air dried basis)			
Al	8700	8300	1100	200	AM5-FBA/6010
Ca	6800	6800	5600	500	AM5-FBA/6010
Fe	300	300	700	100	AM5-FBA/6010
Mg	2900	2900	2300	100	AM5-FBA/6010
Ni	< 30	< 30	< 30	30	AM5-FBA/6010
Ti	400	400	300	100	AM5-FBA/6010

Approved [signature]

Report Date 4/3/95

ANALYTICAL LABORATORY SERVICES REQUEST

'erhaeuser Research and Development – Analysis and Testing

		Request Number: 17407
:le: PELLERIN MILNOR LIQUID SAMPLES		
ıber of Samples: 4	Project Number: 092-2040	Groups: 3,4
:e Received: 03/08/95	Date Desired: 03/29/95	Sample Disposition:
ɔmitted By: BECK, DARLENE	Location: WTC 2B19	Ph: 924-6112
'iewed By: RANTA Maxine	Location: WTC 2F25	Ph: 924-6149/6289
ɔject Title:	Project Leader:	
ɔy To: JAN HUSTON - WTC 2B19		

ıple Description and History:

ɔup	Series	Test Description		
		Report Range	Report Basis	Lower Limit of Sensitivity
3	B	ICP Scan		
3	B	Silicon/Silica		
4	A	BOD5		
4	A	Chloride		
4	A	pH of Waters		
4	A	Solids, Total Dissolved (TDS)		
4	A	Solids, Total Suspended (TSS)		

ımple Number	Series to Be Evaluated	Submitters Designation	Date Recd
43241	AB	MCDB CLARIFIER FEED 03/06/95	03/08/95
43242	AB	MCDB CLARIFIER EFFLUENT 03/06/95	03/08/95
43243	AB	CUP CLARIFIER FEED 03/06/95	03/08/95
43244	AB	CUP CLARIFIER EFFLUENT 03/06/95	03/08/95

ference: 15793			Record Book:
sults Approved:	Date:	Signature Applies To Attached Pages:	Page Numbers: To:

inted on: 03/08/95 at 14:16:01

Request 17407

WEYERHAEUSER TECHNOLOGY CENTER
Analytical Laboratories
Tacoma, Washington

REPORT

Pellerin Milnor Liquid Samples
03/06/95

Sample Designation		MCDB Clarifier Feed	MCDB Clarifier Effluent	CUP Clarifier Feed	CUP Clarifier Effluent	
Analytical Lab Code		43241	43242	43243	43244	
TEST	**UNIT**					**Method Used:**
Ph		12.0	11.3	10.9	10.0 ; 10.0	**EPA 150.1**
TDS	**mg/L**	1,420 ; 1,380	940	530	440	**EPA 160.1**
TSS	**mg/L**	870 ; 870	10	920	40	**EPA 160.2**
BOD	**mg/L**	230	170	290 *	49 *	**SM 5210**
Cl	**mg/L**	46 ; 48	42	27	26	**EPA 352.1**

* Highest valid value; very eratic values observered

Approved [signature] Date 4/18/95

WEYERHAEUSER COMPANY
ANALYTICAL LABORATORIES
ATOMIC SPECTROSCOPY
Tacoma, WA

Pellerin Milnor Liquid Samples
SR 17407
Method: AM1-3010/6010
Total Metals Analysis

Element	43241 MCDB Clarifier Feed	43241D Duplicate	43242 MCDB Clarifier Effluent	43243 CUP Clarifier Feed	43244 CUP Clarifier Effluent	Quantitation Limit
			(ug/L)			
Ag	< 10	< 10	< 10	< 10	< 10	10
Al	2000	1900	900	4000	2500	200
As	< 100	< 100	< 100	< 100	< 100	100
B	< 500	< 500	< 500	< 500	< 500	500
Ba	< 100	< 100	< 100	< 100	< 100	100
Be	< 10	< 10	< 10	< 10	< 10	10
Bi	< 50	< 50	< 50	< 50	< 50	50
Ca	12900	12700	16100	22300	18800	500
Cd	< 10	< 10	< 10	< 10	< 10	10
Co	< 10	< 10	< 10	< 10	< 10	10
Cr	10	10	< 10	< 10	< 10	10
Cu	40	40	60	30	< 20	20
Fe	1100	1000	< 100	200	< 100	100
K	< 10000	< 10000	< 10000	< 10000	< 10000	10000
Li	< 50	< 50	< 50	< 50	< 50	50
Mg	2000	2000	600	5400	4500	100
Mn	30	30	< 10	< 10	< 10	10
Mo	50	40	30	40	20	10
Na	473000	485000	273000	160000	102000	1000
Ni	< 30	< 30	< 30	< 30	< 30	30
P	900	900	400	500	300	200
Pb	< 50	< 50	< 50	< 50	< 50	50
Sb	< 50	< 50	< 50	< 50	< 50	50
Se	< 500	< 500	< 500	< 500	< 500	500
Sn	< 50	< 50	< 50	< 50	< 50	50
Sr	60	60	70	100	90	10
Tl	< 500	< 500	< 500	< 500	< 500	500
V	< 10	< 10	< 10	< 10	< 10	10
Zn	120	120	< 20	30	< 20	20

Approved Julie Reimer

Report Date 03/23/95

WEYERHAEUSER COMPANY
ANALYTICAL LABORATORIES
ATOMIC SPECTROSCOPY
Tacoma, WA

Pellerin Milnor Liquid Samples
SR 17407
Method: EPA 200.7
Dissolved Metals Analysis

Element	43241 MCDB Clarifier Feed	43242 MCDB Clarifier Effluent	43243 CUP Clarifier Feed	43244 CUP Clarifier Effluent	Quantitation Limit
			(ug/L)		
Si as SiO2	14300	11700	7100	6900	500

Approved [signature] Report Date 3/23/95

CYTEC

Process Water Clarification Data for 3/6/95 Pilot Plant Run at Pellerin Milnor for Weyerhaeuser Technical Center

	Clarification Treatment Program			Clarifier Influent			Clarifier Effluent		% TSS	Krofta Mat
	Dosage (ppm)		Est. Cost							
Time	Magnifloc 573C	Magnifloc AF126	$/1000 gal.	pH	Temp. (deg F)	TSS (ppm)	Turbidity (NTU)	TSS (ppm)	Removal	% Solids
10:45	2.0	2.0	0.03	10.4	143		21			
11:30	2.0	2.0	0.03	10.7	135					
12:15	2.0	2.0	0.03	10.8		34,476	28	38	99.9	
13:00	3.6	2.0	0.04	10.8	128	800	9	48	94.0	4.0
16:30	3.0	4.0	0.06	10.1	119	470	33	67	85.7	2.1
17:00	2.0	6.0	0.07	10.2		510	20	35	93.1	2.5

Background Information:

1. Process water flow to the Krofta clarifier = 50 GPM.
2. Main source of process water for clarification is the filtrate from the side-hill screen thickener.
3. Condensed log of events:
   a. Data collected from 10:45 to 13:00 was on drink box furnish
   b. 10:45 sample was prior to any significant amounts of pulp passing over the side-hill screen
   c. At the 11:30 sample, pulp was passing over the side-hill screen
   d. From 11:30 to 12:45, mechanical problems were experienced on the Krofta. This resulted in intermittent carry-over of the sludge mat to the clarifier effluent. This explains why the 12:15 influent solids to the Krofta were so high. For a short period, solids recirculated in the water loop & built up to higher than normal levels.
   e. Data collected at 16:30 and 17:00 was on cup stock furnish.
4. Description of the dual component, clarification treatment program:
   a. Magnifloc 573C is a polyamine based chemistry. It was used as the cationic coagulant.
   b. Magnifloc AF126 is an anionic, polyacrylamide based, emulsion product. It was used as the flocculant.

CYTEC *Water & Recycle Technology Group*

March 7, 1995

Ms. Darlene Beck
Weyerhaeuser Company
Mail Stop 2B19
Tacoma, WA 98477

Subject: Process Water Clarification Data for 3/6/95 Pilot Plant Evaluation at Pellerin Milnor

Dear Darlene:
I really enjoyed working with you during the pilot plant work at Pellerin Milnor. As you know, during all phases of the evaluation, a Cytec treatment program was used for clarification of the process water. We used a dual component program consisting of: Magnifloc 573C, a cationic coagulant and Magnifloc AF126, an anionic flocculant. The Magnifloc AF126 is relatively new product for Cytec. In 1994, we introduced the Magnifloc AF100 Series to the industry. The series consists of four, differently charged anionic flocculants. The unique characteristic of this group of polymers is that they possess exceptionally high molecular weights (3 to 4 times higher than conventional anionic emulsions). It has been our experience that this feature allows significant improvements in clarification efficiencies to be obtained, at reduced dosage levels. And, not only is the flocculant dosage requirement reduced, but it also results in lower dosage requirements of the cationic coagulant! We are currently using Magnifloc AF100-type programs on 20 clarifiers in the recycling segment of the paper industry. On a daily basis, almost 5000 tons of recycle pulp are manufactured in the facilities where these clarifiers are located.

Darlene, I am attaching a summary of the clarification data collected during the 3/6/95 pilot plant evaluation. If you have any questions regarding this information, please do not hesitate to give me a call. I realize that this project is still in the developmental phases for Weyerhaeuser; however, if it is decided to pursue further pilot studies or to proceed with a full-scale installation, please keep us in mind for the clarification portion of the process.

I look forward to working with you in the future.

Sincerely yours,

Pamela A. Lentz
Cytec Industries Inc.
Water & Recycle Technology Group Manager

cc: Mr. Chris Kulakowski - Pellerin Milnor Corporation

APPENDIX 3

TAPPI TEST METHOD NUMBERS

APPENDIX 3

TAPPI TEST METHOD NUMBERS

Test Performed	Corresponding TAPPI Number
Brightness	T 452 om-92
Dirt Count	Weyerhaeuser Method D-1
Debris	Weyerhaeuser Method W-120-0
Freeness	Weyerhaeuser Method W-040-2
Consistency	Weyerhaeuser Method W-025-0
Basis weight	T 410 om-93
Caliper	T 411 om-89
Density	N/A, Calculated
Bulk	N/A, Calculated
Burst Index	T 403 om-91
Tear Index	T 414 om-88
Tensile	T 404 cm-92
Elongation	T 404 cm-92
Tensile Index	T 404 cm-92
TEA	T 404 cm-92
Breaking Length	T 404 cm-92

APPENDIX 4

OPERATING COST DATA, UNITS OF CONSUMPTION, & UNIT COST

APPENDIX 4

OPERATING COST DATA, UNITS OF CONSUMPTION, & UNIT COST

The following assumptions have been used to estimate operating costs for a commercial scale installation of a Pellerin Milnor continuous batch fiber recovery system. For the purpose of this operating cost estimate it is assumed that output tonnage is held constant based on data supplied by Pellerin Milnor for 24 modules and for 48 modules.

MAJOR ASSUMPTIONS

- Units of consumption for 7 module system will be the same for 24 module system.
- System modifications to improve quality will not affect units of consumption.
- All tons are short tons, bone dry tons are used for the finish product. Scale weight tons assumes actual measured consistency at the Sept. 94 pilot plant trial of 88.6% for milk carton and 93.4% for cup stock.
- Raw material pricing is based on scale weight tons (SWT)
- System availability is 95%.
- Labor requirements assumes that 1 maintenance person can cover all maintenance. Operations includes 1 material handling person per shift (raw materials, chemicals, rejects, etc.) and one process person per shift.
- Labor rate assumes $12.50/hour for process and material handling position and $15.00/hour for maintenance. A loading multiplier of 1.5 is used to account for overtime, and benefits.
- It is assumed that no salaried labor is required.
- Average freight is assumed at $25/SWT of raw material.
- Flow to the clarifier is calculated on a flow per ton basis. The material balance from the pilot plant trial were used to generate these numbers.
- Effluent from the system was estimated based on a water balance around the system during the pilot plant.
- Clarifier treatment costs are based on the report from Cytex, which included a cost of treatment in $/1000 gallons (Appendix 3).

- Effluent treatment costs are based on a fee structure which includes flow, TSS and BOD. The treatment costs are from an effluent treatment facility in Washington State and will be site dependent.
- Reject disposal cost was estimated at $13/cubic yard. It was assumed that the rejects would be dewatered to 40% consistency prior to disposal.
- The operating cost summary includes ONLY variable costs and labor. All fixed costs including maintenance capital, depreciation, taxes, and regulatory fee's are not included.
- It was assumed that performance properties will be the same for a 7 module system as for a 24 or 48 module system.

Operating Cost Estimations

f680 4a PDF

	Unit	Cost/Unit	Milk Carton	Milk Carton
PRODUCTION				
Ave Daily	BDST		13.50	13.50
Max Daily	BDST		14.21	14.21
Availability	%		95.00	95.00
RAW MATERIAL		$/SWT	120.00	120.00
Yield	% BD to BD		63.80	80.00
Grade			Milk Carton	Milk Carton
LABOR		$/yr		
Maintenance	#	46800	1	1
Material Handling	#	39000	4	4
Process	#	39000	4	4
CHEMICALS		$/#		
NaOH	#/SWT	0.16	25	25
H2O2	#/SWT	0.38	40	40
Polymer	gal/BDT		58700	58700
ENERGY				
Electricity	kWh/ADMT	0.0184 $/kwh	38.85	38.85
Steam	lb/hr	2.41	90	90
WASTE		$13/yd3		
Dry Tons/day	BDT/Day		7.66	3.38
Wet Tons/day	Ton/Day		19.15	8.44
Ton sludge/ton pulp			1.42	0.63
EFFLUENT				
Flow	gal/ton	$0.73/kgal	5400	5400
TSS	#/day		18.846	18.846
BOD	**#/day**		**0.000**	**0.000**

Operating Cost Estimations

	Unit	Cost/Unit		
PRODUCTION			Milk Carton	Milk Carton
Ave Daily	BDST		13.50	13.50
Yearly Production	BDST		4887	4887
RAW MATERIAL		$/SWT	145	145
Yield	% BD to BD	$/BDST Pulp	256.515	204.571
LABOR	$/BDST		73.419	73.419
Maintenance		$/BDST	9.576	9.576
Material Handling		$/BDST	31.921	31.921
Process		$/BDST	31.921	31.921
CHEMICALS			31.855	25.761
NaOH	$/BDST	0.16	6.270	5.000
H2O2		0.38	23.824	19.000
Polymer	$/gal	0.00003	1.761	1.761
		0.000065		
ENERGY			1.213	1.213
Electricity	$/BDST	0.0184	0.715	0.715
Natural Gas	lb/hr	2.8	0.498	0.498
WASTE		13	22.129	9.750
Dry Tons/day	BDT/Day		7.660	3.375
Wet Tons/day	Ton/Day		19.150	8.438
Ton sludge/ton pulp			1.418	0.625
EFFLUENT		**$/BDT**	**3.977**	**3.977**
Flow $/Mgal	0.73	$/BDT	3.942	3.942
TSS $/Klb	25		0.035	0.035
BOD $/Klb	**60**		**0.000**	**0.000**
FRESH WATER	5367	0.16	0.064	0.064
TOTAL VARIABLE COST			389.171	318.755

Operating Cost Estimations

	Unit	Cost/Unit	Milk Carton	Milk Carton
PRODUCTION				
Ave Daily	BDST		27.20	27.20
Max Daily	BDST		28.63	28.63
Availability	%		95.00	95.00
RAW MATERIAL		$/SWT	120.00	120.00
Yield	% BD to BD		63.80	80.00
Grade			Milk Carton	Milk Carton
LABOR		$/yr		
Maintenance	#	46800	1	1
Material Handling	#	39000	4	4
Process	#	39000	4	4
CHEMICALS		$/#		
NaOH	#/SWT	0.16	25	25
H2O2	#/SWT	0.38	40	40
Polymer	gal/BDT		58700	58700
ENERGY				
Electricity	kWh/ADMT	0.0184 $/kwh	38.85	38.85
Steam	lb/hr	2.41	90	90
WASTE		$13/yd3		
Dry Tons/day	BDT/Day		15.43	6.80
Wet Tons/day	Ton/Day		38.58	17.00
Ton sludge/ton pulp			1.42	0.63
EFFLUENT				
Flow	gal/ton	$0.73/kgal	5400	5400
TSS	#/day		37.971	37.971
BOD	**#/day**		**0.000**	**0.000**

Operating Cost Estimations

	Unit	Cost/Unit		
PRODUCTION			Milk Carton	Milk Carton
Ave Daily	BDST		27.20	27.20
Yearly Production	BDST		9846	9846
RAW MATERIAL		$/SWT	145	145
Yield	% BD to BD	$/BDST Pulp	256.515	204.571
LABOR	$/BDST		36.440	36.440
Maintenance		$/BDST	4.753	4.753
Material Handling		$/BDST	15.843	15.843
Process		$/BDST	15.843	15.843
CHEMICALS			31.855	25.761
NaOH	$/BDST	0.16	6.270	5.000
H2O2		0.38	23.824	19.000
Polymer	$/gal	0.00003	1.761	1.761
		0.000065		
ENERGY			0.962	0.962
Electricity	$/BDST	0.0184	0.715	0.715
Natural Gas	lb/hr	2.8	0.247	0.247
WASTE		13	22.129	9.750
Dry Tons/day	BDT/Day		15.433	6.800
Wet Tons/day	Ton/Day		38.583	17.000
Ton sludge/ton pulp			1.418	0.625
EFFLUENT		**$/BDT**	**3.977**	**3.977**
Flow $/Mgal	0.73	$/BDT	3.942	3.942
TSS $/Klb	25		0.035	0.035
BOD $/Klb	**60**		**0.000**	**0.000**
FRESH WATER	5367	0.16	0.032	0.032
TOTAL VARIABLE COST			351.909	281.492

Operating Cost Estimations

	Unit	Cost/Unit	Milk Carton	Milk Carton
PRODUCTION				
Ave Daily	BDST		13.50	27.20
Max Daily	BDST		14.21	28.63
Availability	%		95.00	95.00
RAW MATERIAL		$/SWT	150.00	150.00
Yield	% BD to BD		63.80	63.80
Grade			Milk Carton	Milk Carton
LABOR		$/yr		
Maintenance	#	46800	1	1
Material Handling	#	39000	4	4
Process	#	39000	4	4
CHEMICALS		$/#		
NaOH	#/SWT	0.16	25	25
H2O2	#/SWT	0.38	40	40
Polymer	gal/BDT		58700	58700
ENERGY				
Electricity	kWh/ADMT	0.0184 $/kwh	38.85	38.85
Steam	lb/hr	2.41	90	90
WASTE		$13/yd3		
Dry Tons/day	BDT/Day		7.66	15.43
Wet Tons/day	Ton/Day		19.15	38.58
Tons Sludge/BDST Pulp			1.42	1.42
EFFLUENT				
Flow	gal/ton	$0.73/kgal	5400	5400
TSS	#/day		18.846	37.971
BOD	**#/day**		**0.000**	**0.000**

Operating Cost Estimations

	Unit	Cost/Unit		
PRODUCTION			Milk Carton	Milk Carton
Ave Daily	BDST		13.50	27.20
Yearly Production	BDST		4887	9846
RAW MATERIAL		$/SWT	175	175
Yield	% BD to BD	$/BDST Pulp	309.588	309.588
LABOR	$/BDST		73.419	36.440
Maintenance		$/BDST	9.576	4.753
Material Handling		$/BDST	31.921	15.843
Process		$/BDST	31.921	15.843
CHEMICALS			31.855	31.855
NaOH	$/BDST	0.16	6.270	6.270
H2O2		0.38	23.824	23.824
Polymer	$/gal	0.00003	1.761	1.761
		0.000065		
ENERGY			1.213	0.962
Electricity	$/BDST	0.0184	0.715	0.715
Natural Gas	lb/hı	2.8	0.498	0.247
WASTE		13	22.129	22.129
Dry Tons/day	BDT/Day		7.660	15.433
Wet Tons/day	Ton/Day		19.150	38.583
Tons Sludge/ADMT Pulp			1.418	1.418
EFFLUENT		**$/BDT**	**3.977**	**3.977**
Flow $/Mgal	0.73	$/BDT	3.942	3.942
TSS $/Klb	25		0.035	0.035
BOD $/Klb	**60**		**0.000**	**0.000**
FRESH WATER	5367	0.16	0.064	0.064
TOTAL VARIABLE COST			442.244	405.013

Operating Cost Estimations

	Unit	Cost/Unit	Milk Carton	Milk Carton
PRODUCTION				
Ave Daily	BDST		13.50	27.20
Max Daily	BDST		14.21	28.63
Availability	%		95.00	95.00
RAW MATERIAL		$/SWT	150.00	150.00
Yield	% BD to BD		80.00	80.00
Grade			Milk Carton	Milk Carton
LABOR		$/yr		
Maintenance	#	46800	1	1
Material Handling	#	39000	4	4
Process	#	39000	4	4
CHEMICALS		$/#		
NaOH	#/SWT	0.16	25	25
H2O2	#/SWT	0.38	40	40
Polymer	gal/BDT		58700	58700
ENERGY				
Electricity	kWh/ADMT	0.0184 $/kwh	38.85	38.85
Steam	lb/hr	2.41	90	90
WASTE		$13/yd3		
Dry Tons/day	BDT/Day		3.38	6.80
Wet Tons/day	Ton/Day		8.44	17.00
Ton sludge/ton pulp			0.63	0.63
EFFLUENT				
Flow	gal/ton	$0.73/kgal	5400	5400
TSS	#/day		18.846	37.971
BOD	#/day		0.000	0.000

Operating Cost Estimations

	Unit	Cost/Unit		
PRODUCTION			Milk Carton	Milk Carton
Ave Daily	BDST		13.50	27.20
Yearly Production	BDST		4887	9846
RAW MATERIAL		$/SWT	175	175
Yield	% BD to BD	$/BDST Pulp	246.896	246.896
LABOR	$/BDST		73.419	36.440
Maintenance		$/BDST	9.576	4.753
Material Handling		$/BDST	31.921	15.843
Process		$/BDST	31.921	15.843
CHEMICALS			25.761	25.761
NaOH	$/BDST	0.16	5.000	5.000
H2O2		0.38	19.000	19.000
Polymer	$/gal	0.00003	1.761	1.761
		0.000065		
ENERGY			1.213	0.962
Electricity	$/BDST	0.0184	0.715	0.715
Natural Gas	lb/hr	2.8	0.498	0.247
WASTE		13	9.750	9.750
Dry Tons/day	BDT/Day		3.375	6.800
Wet Tons/day	Ton/Day		8.438	17.000
Ton sludge/ton pulp			0.625	0.625
EFFLUENT		**$/BDT**	**3.977**	**3.977**
Flow $/Mgal	0.73	$/BDT	3.942	3.942
TSS $/Klb	25		0.035	0.035
BOD $/Klb	**60**		**0.000**	**0.000**
FRESH WATER	5367	0.16	0.064	0.064
TOTAL VARIABLE COST			361.080	323.849

Operating Cost Estimations

	Unit	Cost/Unit	Milk Carton	Milk Carton
PRODUCTION				
Ave Daily	BDST		13.50	27.20
Max Daily	BDST		14.21	28.63
Availability	%		95.00	95.00
RAW MATERIAL		$/SWT	120.00	120.00
Yield	% BD to BD		87.00	87.00
Grade			Milk Carton	Milk Carton
LABOR		$/yr		
Maintenance	#	46800	1	1
Material Handling	#	39000	4	4
Process	#	39000	4	4
CHEMICALS		$/#		
NaOH	#/SWT	0.16	25	25
H2O2	#/SWT	0.38	40	40
Polymer	gal/BDT		58700	58700
ENERGY				
Electricity	kWh/ADMT	0.0184 $/kwh	38.85	38.85
Steam	lb/hr	2.41	90	90
WASTE		$13/yd3		
Dry Tons/day	BDT/Day		2.02	4.06
Wet Tons/day	Ton/Day		5.04	10.16
Ton sludge/ton pulp			0.37	0.37
EFFLUENT				
Flow	gal/ton	$0.73/kgal	5400	5400
TSS	#/day		18.846	37.971
BOD	**#/day**		**0.000**	**0.000**

Operating Cost Estimations

	Unit	Cost/Unit		
PRODUCTION			Milk Carton	Milk Carton
Ave Daily	BDST		13.50	27.20
Yearly Production	BDST		4887	9846
RAW MATERIAL		$/SWT	145	145
Yield	% BD to BD	$/BDST Pulp	188.111	188.111
LABOR	$/BDST		73.419	36.440
Maintenance		$/BDST	9.576	4.753
Material Handling		$/BDST	31.921	15.843
Process		$/BDST	31.921	15.843
CHEMICALS			23.830	23.830
NaOH	$/BDST	0.16	4.598	4.598
H2O2		0.38	17.471	17.471
Polymer	$/gal	0.00003	1.761	1.761
		0.000065		
ENERGY			1.213	0.962
Electricity	$/BDST	0.0184	0.715	0.715
Natural Gas	lb/hr	2.8	0.498	0.247
WASTE		13	5.828	5.828
Dry Tons/day	BDT/Day		2.017	4.064
Wet Tons/day	Ton/Day		5.043	10.161
Ton sludge/ton pulp			0.374	0.374
EFFLUENT		**$/BDT**	**3.977**	**3.977**
Flow $/Mgal	0.73	$/BDT	3.942	3.942
TSS $/Klb	25		0.035	0.035
BOD $/Klb	**60**		**0.000**	**0.000**
FRESH WATER	5367	0.16	0.064	0.064
TOTAL VARIABLE COST			296.441	259.211

Operating Cost Estimations

	Unit	Cost/Unit	Milk Carton	Milk Carton
PRODUCTION				
Ave Daily	BDST		13.50	27.20
Max Daily	BDST		14.21	28.63
Availability	%		95.00	95.00
RAW MATERIAL		$/SWT	150.00	150.00
Yield	% BD to BD		87.00	87.00
Grade			Milk Carton	Milk Carton
LABOR		$/yr		
Maintenance	#	46800	1	1
Material Handling	#	39000	4	4
Process	#	39000	4	4
CHEMICALS		$/#		
NaOH	#/SWT	0.16	25	25
H2O2	#/SWT	0.38	40	40
Polymer	gal/BDT		58700	58700
ENERGY				
Electricity	kWh/ADMT	0.0184 $/kwh	38.85	38.85
Steam	lb/hr	2.41	90	90
WASTE		$13/yd3		
Dry Tons/day	BDT/Day		2.02	4.06
Wet Tons/day	Ton/Day		5.04	10.16
Ton sludge/ton pulp			0.37	0.37
EFFLUENT				
Flow	gal/ton	$0.73/kgal	5400	5400
TSS	#/day		18.846	37.971
BOD	**#/day**		**0.000**	**0.000**

Operating Cost Estimations

	Unit	Cost/Unit		
PRODUCTION			Milk Carton	Milk Carton
Ave Daily	BDST		13.50	27.20
Yearly Production	BDST		4887	9846
RAW MATERIAL		$/SWT	175	175
Yield	% BD to BD	$/BDST Pulp	227.031	227.031
LABOR	$/BDST		73.419	36.440
Maintenance		$/BDST	9.576	4.753
Material Handling		$/BDST	31.921	15.843
Process		$/BDST	31.921	15.843
CHEMICALS			23.830	23.830
NaOH	$/BDST	0.16	4.598	4.598
H2O2		0.38	17.471	17.471
Polymer	$/gal	0.00003	1.761	1.761
		0.000065		
ENERGY			1.213	0.962
Electricity	$/BDST	0.0184	0.715	0.715
Natural Gas	lb/hr	2.8	0.498	0.247
WASTE		13	5.828	5.828
Dry Tons/day	BDT/Day		2.017	4.064
Wet Tons/day	Ton/Day		5.043	10.161
Ton sludge/ton pulp			0.374	0.374
EFFLUENT		**$/BDT**	**3.977**	**3.977**
Flow $/Mgal	0.73	$/BDT	3.942	3.942
TSS $/Klb	25		0.035	0.035
BOD $/Klb	**60**		**0.000**	**0.000**
FRESH WATER	5367	0.16	0.064	0.064
TOTAL VARIABLE COST			335.361	298.131

APPENDIX 5

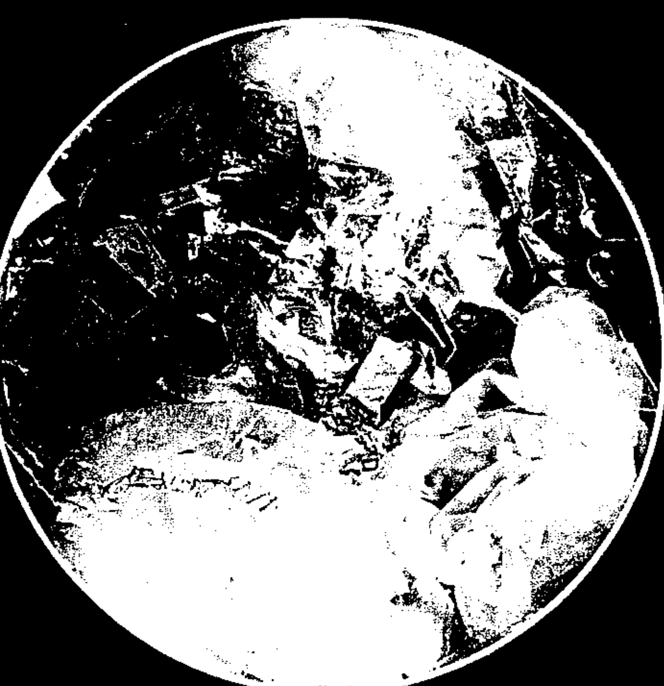
COMPANY INFORMATION

PROGRESS IN PAPER RECYCLING

Volume 4, Number 2 February 1995

Raw materials, milk cartons

Base stock enters load chute of cleaner



Contaminants removed by the process

Cleaned pulp from the process

"Laundering Recovered Paper", see p. 12

FINALLY, A FIBER RECOVERY SYSTEM THAT'S COST-EFFICIENT.

The continuous batch system from Pellerin Milnor.

Here is breakthrough technology in paper recycling – a fiber recovery system with both low capital cost and low operating expenses. It's a continuous batch fiber recovery system from Pellerin Milnor. It provides high-dilution fiber washing for deinking. It can also separate fiber from polyester film used in milk cartons, drink boxes, poly-coated cups, etc.

Continuous batch technology is a system of connected modules, each with an outer shell and rotating inner cylinder. Each module has an integrated transfer scoop, which transfers stock from one stage to the next – simply and efficiently, without pumps. Rejected polyfilm is removed in sheets and/or large pieces (not ground and then separated).

Extensive factory testing has revealed significant advantages. Here is a summary. For more information, please contact us.

AFFORDABLE: The system's simplicity helps reduce capital costs. Even the integrated solid state controls cost less than others.

LOW OPERATING COSTS: Saves water (most is reused in the closed loop system; tests show consumption of .5 to 1 gal./lb.) and electricity (energy-consuming pumps are not needed for stock transfers within a system).

FASTER INSTALLATION: Typically, a system can be installed within the range of four weeks. System includes virtually all internal piping and wiring, as well as controls. There are single-point connections for water, steam, air and electricity. (Also reduces construction and engineering fees.)

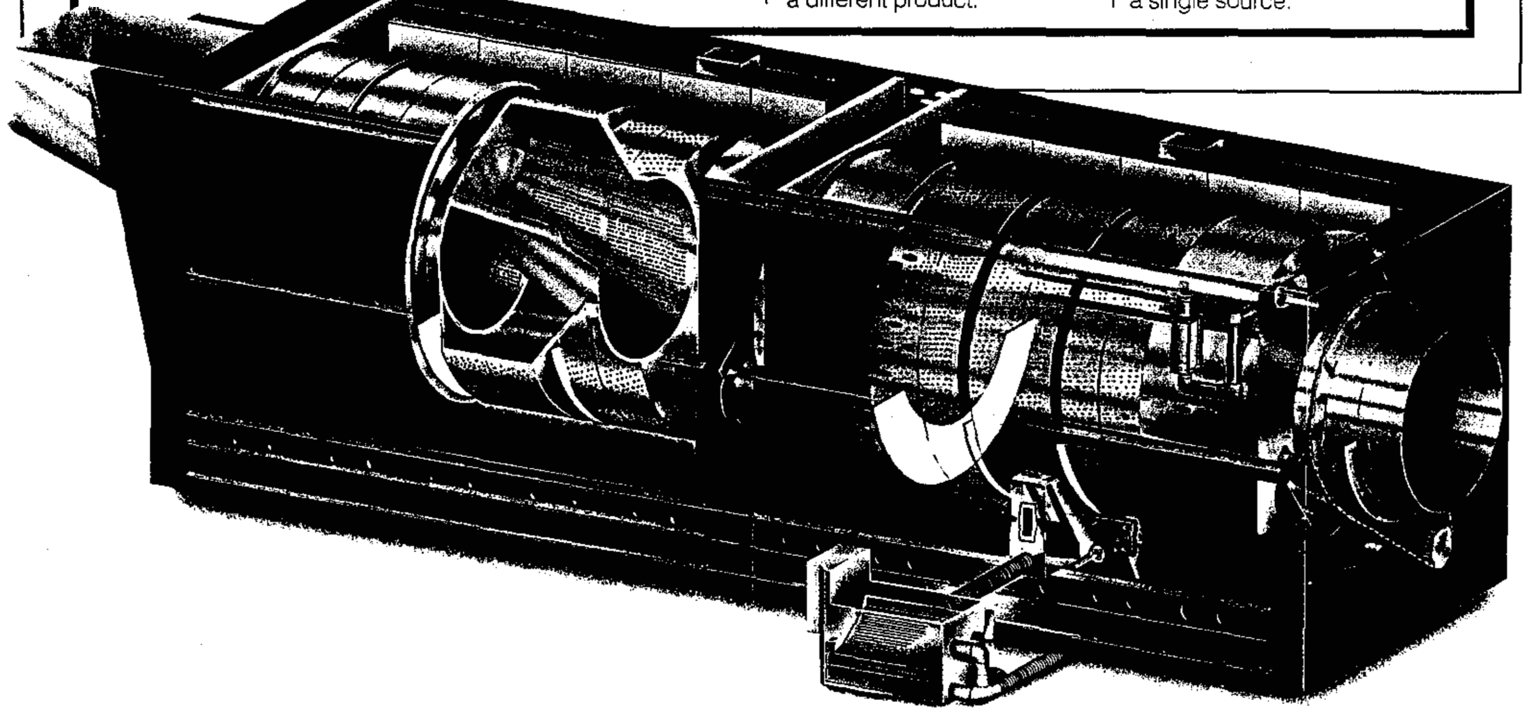
SAVES SPACE: Compact design requires far less space than other systems.

EASY OPERATION: Base stock is loaded by materials handling systems. From there operation is automatic – controlled by programmable microprocessors with informative data displays.

EASILY STAGED: You can increase volume as necessary by adding more production lines (or adding modules within one line). You can also segment your operation better by devoting a separate line to a different product.

PROVEN TECHNOLOGY: This type of system has been proven in the laundry industry, which has many parallels to the paper industry. More than 7,000 modules have been installed worldwide since the late 1970's.

TURNKEY INSTALLATION: The complete system is manufactured by Pellerin Milnor. Even solid state controls are designed and built in-house. You deal with a single source.



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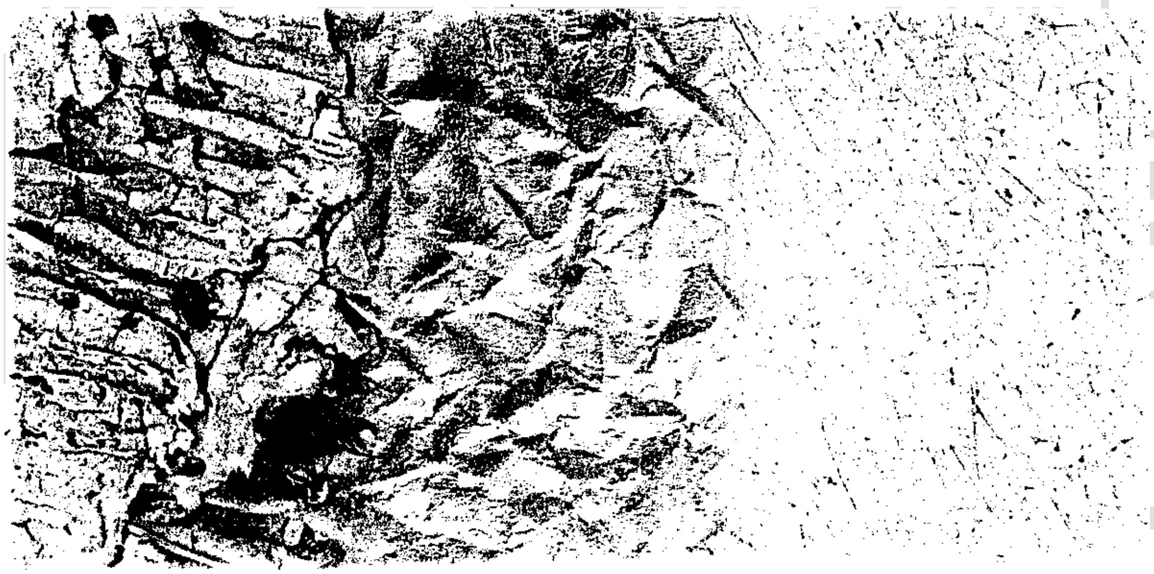


Finally, a fiber recovery system with low capital cost, low operating expenses.

RE GENEX

DIVISION OF PELLERIN MILNOR CORP.

Breakthrough Technology in Paper Recycling...

FIBER RECOVERY SYSTEM

Introducing a new continuous batch fiber recovery system, manufactured by the Regenex Division of Pellerin Milnor Corporation.

This system provides high-dilution fiber washing for deinking. It can also separate fiber from polyester film used in milk cartons, drink boxes, poly-coated cups, and similar items.

Continuous batch technology is a system of connected modules, each with an outer shell and rotating inner cylinder. Each module has an integrated transfer scoop, which transfers stock from one stage to the next – simply and efficiently, without pumps and screens.

The system's outer shell and inner cylinder enable the machine to create two distinct material transfer paths – one for rejected polyfilm and the other for cleaned secondary fiber. Thus, the system solves one of the most difficult problems in processing poly-coated materials – separating polyfilm from fiber and breakdown of wet-strength resins. Rejected polyfilm is removed in sheets and/or large pieces (as opposed to ground into the fiber, and then separated).

TOP TRANSFER FOR HIGH DILUTION

Pulping and washing processes occur in multiple, connected cylinders which rotate in sychronization.

As the cylinder rotates, stock is lifted from the process water and dropped back into the solution. Resulting mechanical action enhances contaminant separation.

Each "batch" moves from module to module by an integrated transfer scoop *(note cutaway at right)*. This scoop lifts stock out of process water and drains it prior to transferring it to the next module. Thus, the transfer scoop provides an intermediate de-watering and dilution at each transfer. The result is fast, efficient processing.

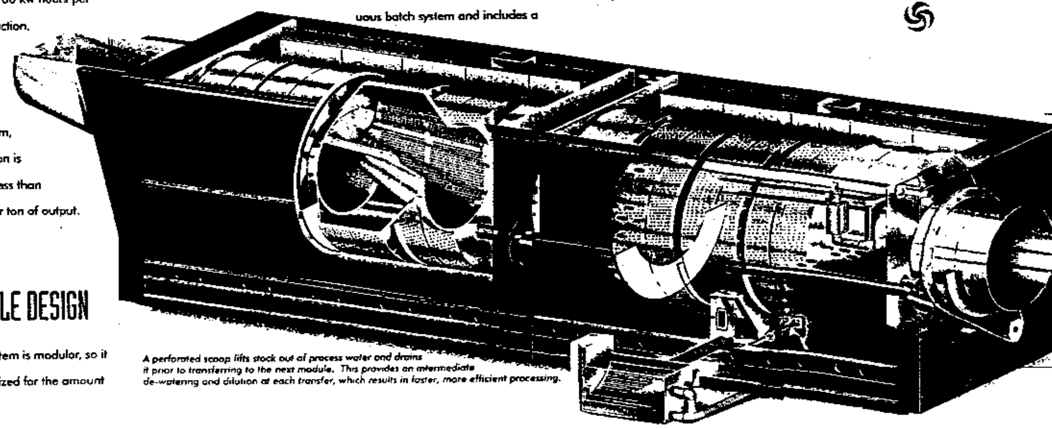
LOW OPERATING COSTS

Because the transfer does not require numerous stages of pumps and screens, energy consumption is typically less than 60 kw hours per daily ton of production.

And because water is reused in the machine's closed-loop system, water consumption is estimated to be less than 1,000 gallons per ton of output.

MODULAR, EXPANDABLE DESIGN

This recovery system is modular, so it can be custom-sized for the amount and type of output required. The system can be configured in any combination of three-or-four module sections. Resulting capacities range from 3 to 250 TPD. Moreover, its modular design allows easy addition of more modules at a later date, should production requirements increase.



A perforated scoop lifts stock out of process water and drains it prior to transferring to the next module. This provides an intermediate de-watering and dilution at each transfer, which results in faster, more efficient processing.

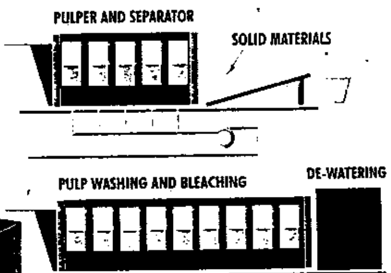
SOPHISTICATED CONTROLS

This fiber recovery system is governed by a serial microprocessor control. The control is designed and manufactured by the Regenex Division of Pellerin Milnor Corporation. It was developed specifically for the continuous batch system and includes a color monitor, keyboard, and printer. The control provides high flexibility, as well as easy installation, operation, troubleshooting, and tracking of individual batches. The microprocessor controls each parameter of processing within each module, including water flow, water temperature, chemical injection, cylinder rotation, drain, refill, etc.

TOTAL SYSTEM CONTROL

The control can also be linked to a computer network system. This system provides central programming, data collection (including hard copies), and monitoring of the entire sytem.

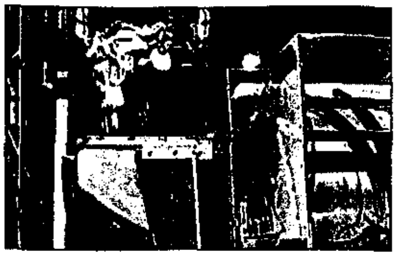
How it works.



Pulp is separated from large sheets of plastic and/or other contaminants in stage 1. Pulp is then transferred to stage 2 where further contaminants are removed and bleaching/neutralizing processes occur.

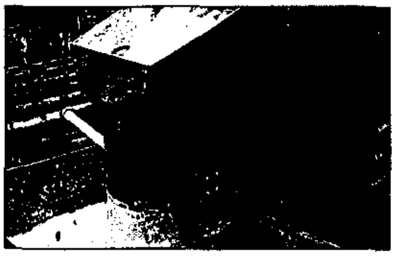
Pulp automatically exits into a de-watering device (optional). After excess moisture is removed, the result is a cake of wet-lap pulp.

1. Raw materials; in this case, cartons.



2. Base stock automatically drops into loading chute of cleaner.

3. Contaminants removed by the process.



4. Cleaned pulp from the process.

5. Final results.

From raw refuse to high-quality fiber – automatically and continually.

/antages of continuous batch fiber recovery system include:

)RDABLE
;implicity of the entire system ; reduce capital costs. Even ntegrated, solid state controls ess than others. The result is r return on investment, par- ırly important for smaller

' OPERATING COSTS
s water (most is reused in the d-loop system; tests show ımption of .5 to 1 gal./lb.) electricity (energy-consuming os are not needed for stock fers within a system).

ʳ OPERATION
stock is loaded by materials lling systems. From there, ation is automatic – con- :d by programmable micro- essors with informative data ays. Versatile and extremely ble user-friendly controls are le to operate. Nor do they ire "babysitting" by the man- turer. Literally hundreds of controls operate day-in- out in laundries worldwide.

CONSISTENT, CONTINUOUS PRODUCTION
The system separates contaminants and washes fiber consistently from batch to batch – and continuously.

The result is a steady flow of batches of output which keeps the mill's production at an even, predictable pace.

FASTER INSTALLATION
Typically, a system can be installed within the range of four weeks. System includes virtually all internal piping and wiring, as well as controls. There are single-point connections for water, steam, air, and electricity. The result is also lower construction and engineering fees.

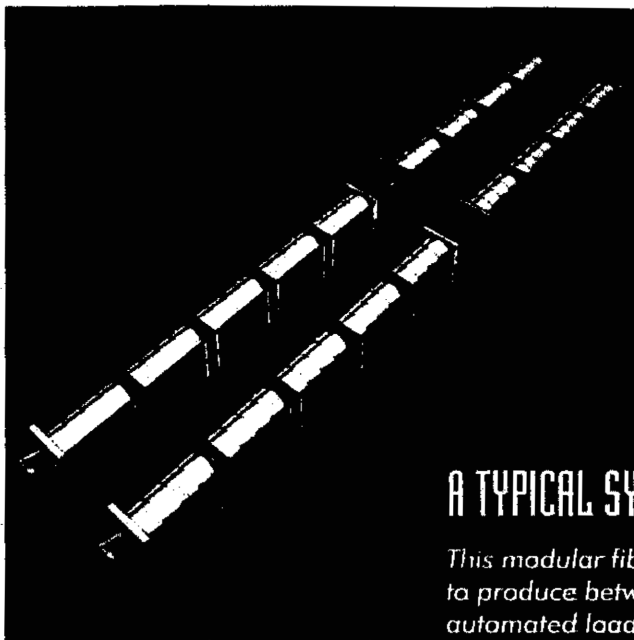
SAVES SPACE
The system's compact design requires far less space than other systems – less than half the floor space of some typical systems.

EASILY STAGED
You can increase volume as necessary by adding more production lines (or adding modules within one line). You can also segment your operation better by devoting a separate line to a different product.

MAINTENANCE EASE
The system requires fewer components than others. The simple drive, for example, requires only two motors per section of several modules. There are no internal seals, *and interior components* are stainless steel. Simple mechanical design limits wear to components. And components are easily accessible to speed maintenance if it is necessary.

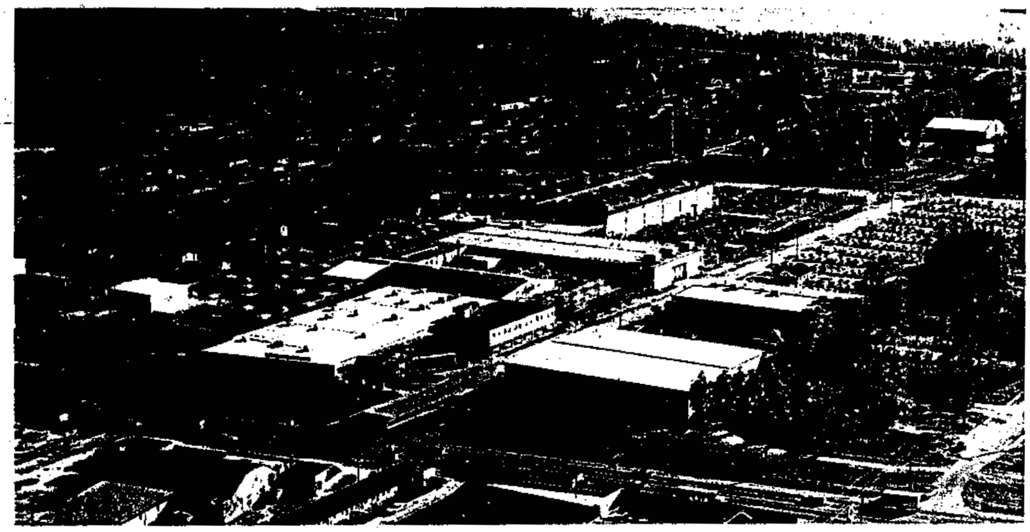
TURNKEY SYSTEMS
All elements of this continuous batch fiber recovery system are available from a single source – including monorail storage systems, fiber recovery systems, materials handling, and controls. The result is an integrated, turnkey installation.

PROVEN TECHNOLOGY
This type of system has been proven in the laundry industry, which has many parallels to the paper industry. More than 7,000 modules have been installed worldwide since the late 1970s.



A TYPICAL SYSTEM

This modular fiber recovery system can be sized to produce between 3 to 250 TPD. A variety of automated loading and unloading devices are available as well. Illustrated is a 50 TPD system with the ability of two-stage bleaching.



QUALITY-ENGINEERED SYSTEMS

Regenex, the manufacturer, is a division of Pellerin Milnor Corporation, a company that is recognized worldwide as the leader in laundry machinery and systems. Founded in 1947, the company backs its products by extensive engineering and manufacturing capabilities, and unrivaled product support. Computer integration – from conceptual design to manufacturing – is used in the development of all products. The company employs over 900 in its 400,000 sq. ft. factory and office facility in suburban New Orleans.

REGENEX
DIVISION OF PELLERIN MILNOR CORP.

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