LAB

ANALYTICAL EVALUATION OF ULTRAFILTRATION FOR REDUCTION OF OILY WASTEWATER

A Technology Demonstration Project

Performed at

B - Line Systems, Inc.

Highland, Illinois

February 1999

by the

Illinois Waste Management and Research Center
One East Hazelwood Drive Champaign, Illinois 61820

EXECUTIVE SUMMARY

On February 10, 1999, a technology demonstration project was conducted at B-Line Systems, Inc. The project successfully demonstrated the use of membrane filtration to separate chemicals in solution, in this case - oil and water.

The demonstration unit used was an ultrafiltration system designed and constructed by WMRC. The filter was an 18-inch, Koch, spiral wound, 0.2 micron membrane. The membrane filtration unit was cleaned prior to use using Koch membrane cleaner and rinsing with de-ionized water. Raw solution from the milling and press sides of the facility, as well as a combination of both, were used as feed stock into the membrane system.

Each sample was thoroughly mixed and introduced into the filtration system. The membrane permeate was collected after allowing the unit to produce flux for five minutes. Each sample was appropriately marked and cataloged for analysis.

The samples were analyzed in the WMRC Analytical Laboratory for percentage of oil and grease, total suspended solids, and for environmental metals of concern. The sampling data was interpreted and reviewed for regulatory compliance - which all samples met.

The demonstration effectively removed 100% of the free and emulsified oils in solution from the feed stocks of both the mill and press sides of the facility.

It should be noted that further analytical analysis determined that a portion of the machine coolant (TC 3130) used on the mill side was also recovered by the membrane filtration system. Data indicated that the membrane permeate was composed of an 18% solution of TC 3130. Presently, B-Line Systems uses a 1:5 or 20% ratio as feed for the 3M mill. It was therefore surmised that the membrane permeate was within acceptable operational parameters.

WMRC recommends that B-Line Systems proceed with further investigation into the use of membrane filtration by renting a full-scale system and installing it on the mill side of the facility to filter the tramp oil from the five milling machines. The unit would reduce the oily wastewater stream and recover TC 3130.

An alternative recommendation would be to install the membrane filtration unit ahead of the tramp oil separator on the 3M mill and to filter the sump solution. Additionally, solutions from the four other milling operations could be batch treated with the 3M mill solution and reused in the 3M mill. This option would keep the 3M milling solution continuously free of contaminants.

BACKGROUND

B-Line Systems operates both a milling and a machine pressing operation. Both operations require machine tool coolant to help produce a quality product and to enhance the life expectancy of the mill rollers and the press machines. Milling units are equipped with cartridge filtration and tramp oil separators (Images 1, 2, and 3) and presses have coolant sumps that are routinely cleaned out by a "sump sucker." Waste oily water, containing coolant, cutting oils, and tramp oils are collected in either 55-gallon drums or 750-gallon tanks. Approximately 30,000 gallons of oily wastewater is disposed of annually at a cost of $20,000.

B-Line requested assistance from WMRC through the Illinois Environmental Protection Agency's Office of Pollution Prevention. An initial site assessment of the B-Line facility was conducted on October 22, 1998 A technical assistance report detailing the site assessment and making recommendation for pollution prevention implementation was issued by WMRC on November 4, 1998.

In January 1999, B-Line contacted WMRC concerning opportunities to reduce their oily wastewater stream. A technical assistance contract was prepared to demonstrate the ability of membrane filtration to separate the oily wastewaters of the milling and pressing operations. On February 10, 1999, an on-site demonstration of ultrafiltration was performed at B-Line Systems.

ULTRAFILTRATION OF AQUEOUS CHEMICALS

Conventional filtration techniques available for recycling aqueous solutions rely on depth or screen filters to remove oil from a process solution. Using these filters, however, can be problematic for the filter media which clogs easily, requiring frequent back flushing or disposal, which results in additional waste. Membrane filtration techniques, such as ultrafiltration, are a more advanced technique that take advantage of thin-filmed membranes and turbulent flow patterns to deliver a more consistent flow rate and a higher quality filtrate (commonly referred to as permeate) than conventional filtration.

The membranes are semipermeable barriers capable of separating feed stream components that have a particle size relative to the pore sizes of the membrane. Feed stream components that have a particle size larger than the pore sizes of the membrane are retained while components that are smaller than the pore sizes of the membrane are allowed to pass through. A major difference between conventional filtration practice and "membrane" filtration is with respect to the mechanism of contaminant capture. Conventional filters operate by capturing particles within the filter matrix, a process termed depth filtration. The filters cannot be regenerated after

Filter System on 3M Mill

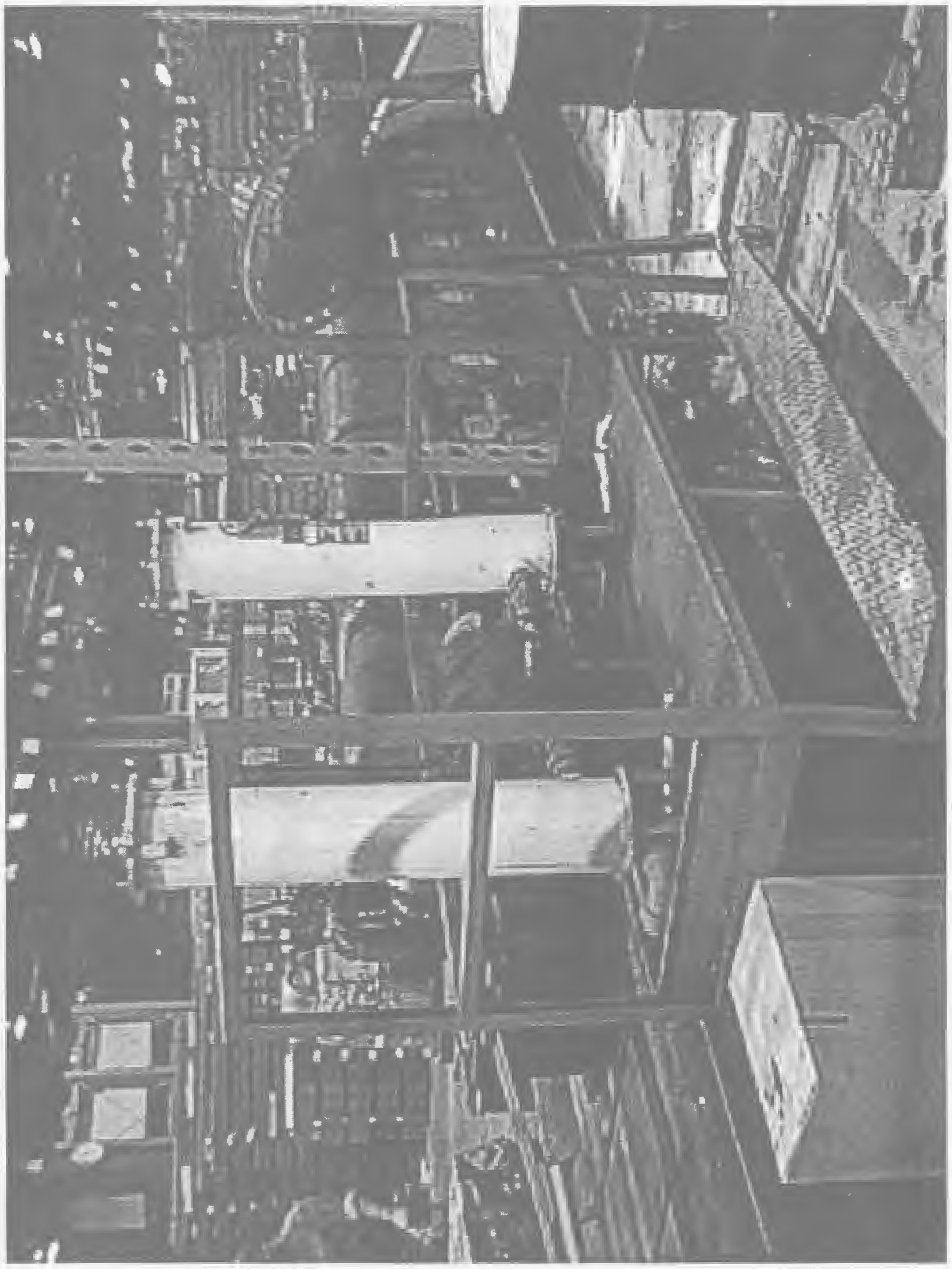


Image 1

Pump, Skimmer and Waste Pail on 3M Mill

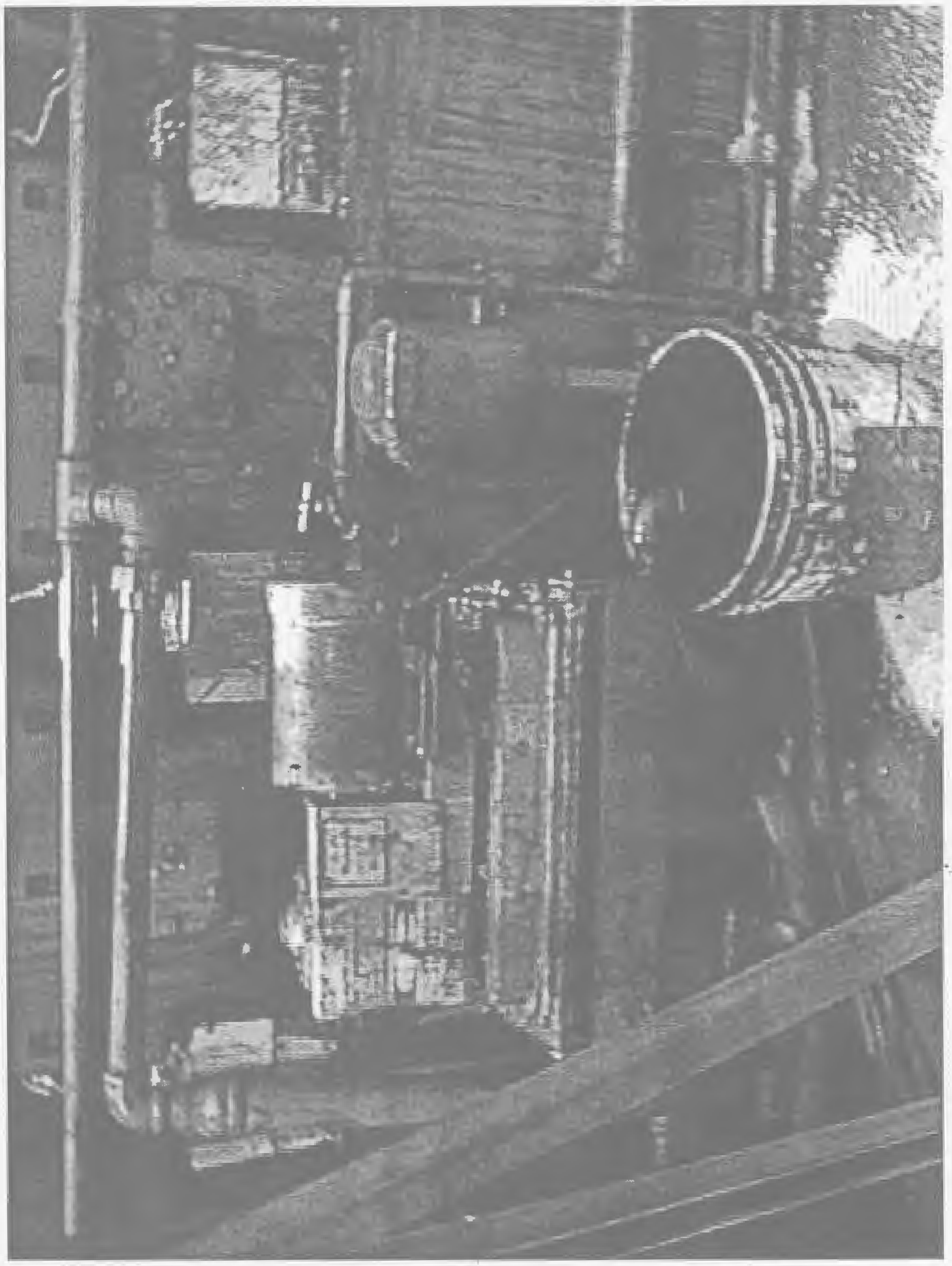


Image 2

Pump, Skimmer and Waste Pail on Other Mill

Image 3

use, as the particles accumulate within the filter matrix. Membrane filters are usually sized to have pores that are too small for particles to enter. Therefore, the bulk of the filtration occurs at the surface of the filter. Membrane filters can, therefore, be reused by removing the particulate matter from the surface by flushing or cleaning. Figure 1 illustrates the common mode of operation employed in ultrafiltration. This mode, termed "cross-flow" filtration, describes the flow of the feed solution in a direction parallel to the membrane surface or filter. This facilitates the "sweeping" of the membrane surface and limits filter cake buildup and allows for longer periods of operation without having to clean the membrane. A small portion of the solution is forced through the membrane by the applied pressure and recovered as "permeate."

The development of more durable membranes, such as polyvinylidene difluoride (PVDF), has expanded the application of membrane filtration beyond its origins in the food industry to successfully handle industrial process solutions with extreme pH's, high temperatures, and high oil concentrations. Because of its unique capabilities to concentrate oily wastewater and produce a clean permeate, ultrafiltration has emerged as a promising technology for extending the life of various solutions. Most of the valuable chemicals present in these solutions pass through the membrane with the permeate and are returned to the process operation. The concentrated oily phase typically comprises a small fraction of the original wastewater volume, so the volume of waste disposed is reduced as are disposal costs.

Previous research performed by Lindsey et. al. (1994 & 1997) on similar of aqueous chemicals suggest that the majority of chemical components will permeate the membrane such that the chemicals can be recycled. The only components in question with respect to recyclability are the surfactants. Surfactants are an important component in machine tool coolants, but typically comprise less than 10% of the total raw chemical formulation. Membrane filtration systems commonly remove some surfactants from the feed stock and could reduce the efficiency of the coolant. It is generally advisable to replenish this lost component to maintain solution parameters.

PROJECT DESCRIPTION

Ultrafiltration System Set-up

A membrane filtration system designed and constructed by the Waste Management and Research Center was used for the demonstration. The filter used was an 18-inch, Koch, spiral wound, 0.2 micron ultrafiltration membrane. The membrane filtration unit was cleaned prior to the demonstration using Koch membrane cleaner and rinsed with de-ionized water. Raw solution from the milling and press sides of the facility, as well as a combination of both, were used as feed stock into the membrane system. Each sample regime was proceeded by rinsing and flushing of the previous sample solution and allowing the rinse water to permeate through the filter to reduce contamination.

A standard drawn tube was used to draw waste feed solution from several levels of the 750-gallon tank adjacent to the 3M mill to ensure representative sampling. The same procedure was followed in the collection of waste press coolant and waste combined mill and press coolant both stored in 55-gallon drums.

Each sample when introduced into the membrane system was allowed to produce permeate,which was returned to the feed tank, for a period of five minutes. A1000 mL sample was then collected in a glass sampling container. Each sample was marked and cataloged for laboratory analysis. Samples of the raw mill, press, and combination solutions were also collected as well as neat (virgin) samples of all chemicals possibly present in the waste feed solutions. Chemicals included TowerChem 3130, MasterChem EP Trim, Houghton Cut-Max 570, TowerSol A 1325, Diversey EGO 80-90, Tower Draw E-610, and Consultant 167-1.

Laboratory Testing

Samples of feed and permeate were collected during the demonstration. All samples were analyzed for the various parameters described below. Oil and grease, and total suspended solids analyses were performed because these parameters represented the primary sources of contamination in the solution. Analysis of metals of environmental concern (regulated by USEPA) were performed because the planned permeate discharge is required to meet all applicable standards and regulations of the City of Highland.

- Oil and Grease - Buildup of this contaminant is one of the primary factors that can deteriorate performance of the coolant. Milling and press lubricants are the principle source of this contaminant in the solution. Analysis of oil and grease was performed by introducing the sample onto a non-polar solid phase oil and grease disk. The disk allows isolation of the oil and grease fraction of the sample, followed by gravimetric analysis. Samples were analyzed using both pH adjusted extractions and non pH adjusted extractions. The primary quality assurance procedures include analysis of blanks, duplicates and spike recoveries.

- Total Suspended Solids - Dirt buildup on metal parts from milling and pressing operations are the principle source of this contaminant. TSS results were obtained using Standard Method 2540. A volume of sample was used in the analyses of the tramp oil samples since the TSS were so high. An analytical duplicate was used to evaluate precision.

- Metals Screening - Metals build-up represents a significant contaminant in machine tool coolant. Additionally, heavy metals are prohibited from discharge to local sewage treatment plants. Samples were thoroughly mixed, digested and then screened for major analytes using the semi-quantitative mode of the inductively coupled mas spectrometer (ICP-MS). Quality control included digested blanks, matrix spikes and laboratory control standards.

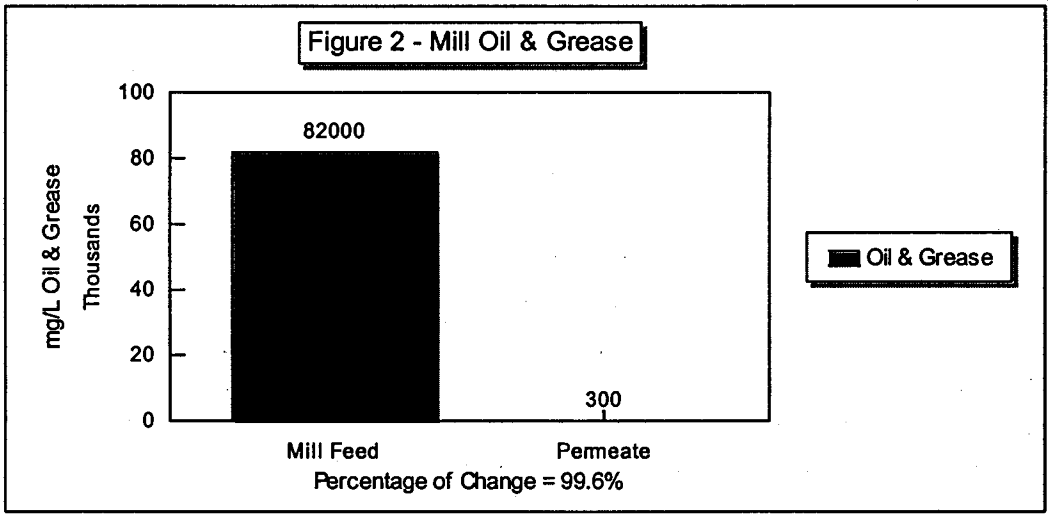
RESULTS AND DISCUSSION

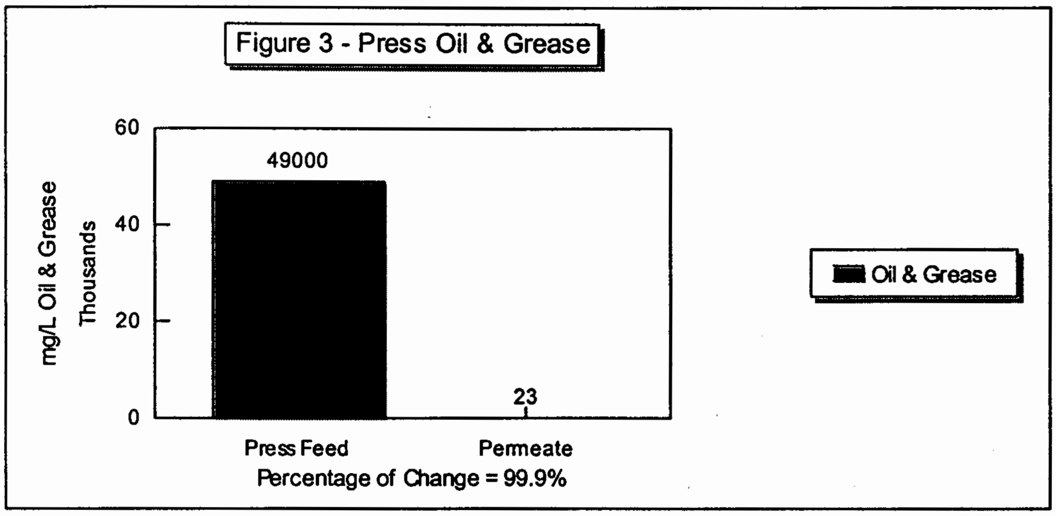
<u>Ultrafiltration System Performance</u>

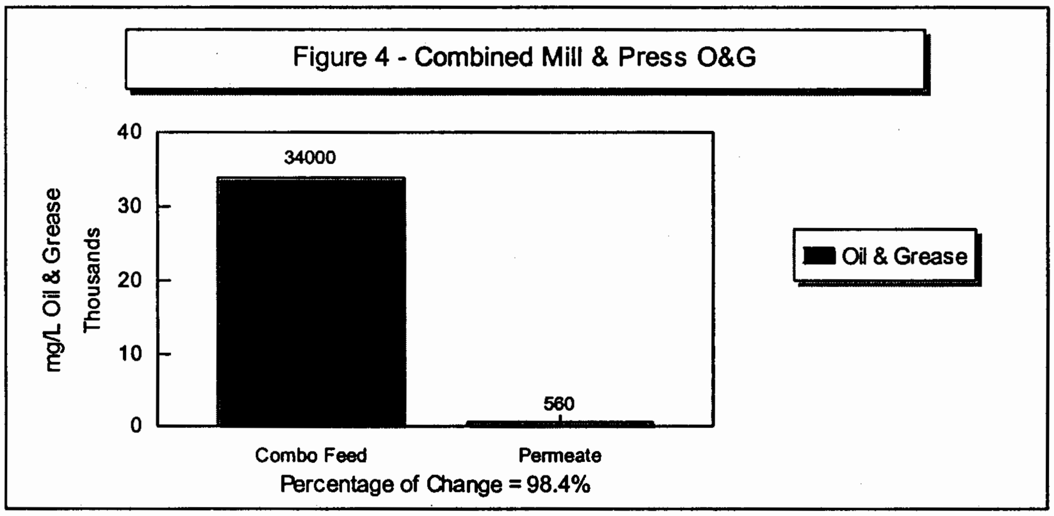
The ultrafiltration system performed as specified with no deviation in performance levels. Input and output pressures were monitored and remained steady throughout the demonstration at 30 psi and 15 psi respectively.

<u>Chemical Analysis</u>

Figures 2, 3, and 4 show the oil and grease levels in the feed and permeate streams. As shown, the oil and grease levels in the permeate were very low concentrations at 23 to 300 mg/L. While feed concentrations were very high at 34,000 to 82,000 mg/L. The data shows that the membrane filter successfully removed approximately 100% of the oil from the wastestream. Although a sample of the feed stock concentrate was not taken, it can be assumed that the oil and grease levels within the concentrate would have exceeded100,000 mg/L.

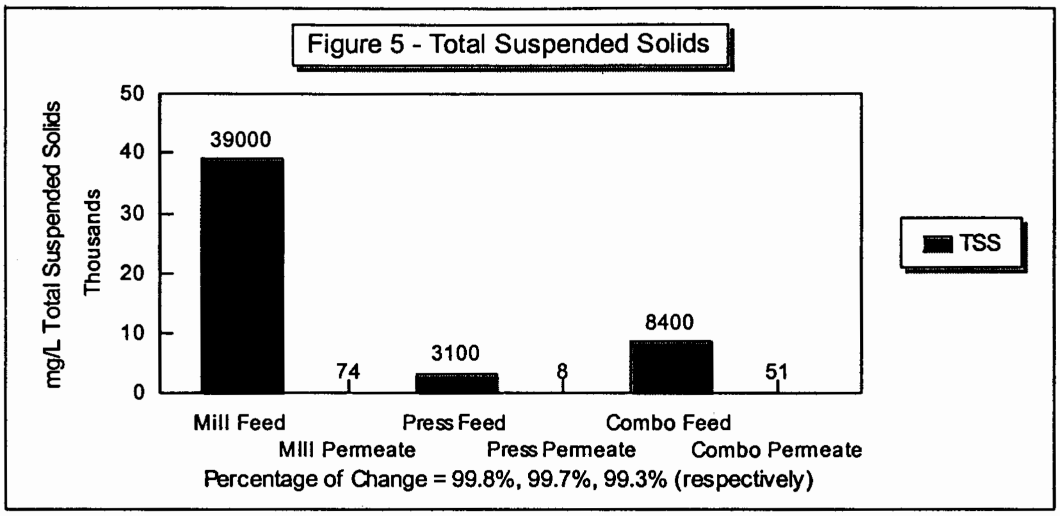




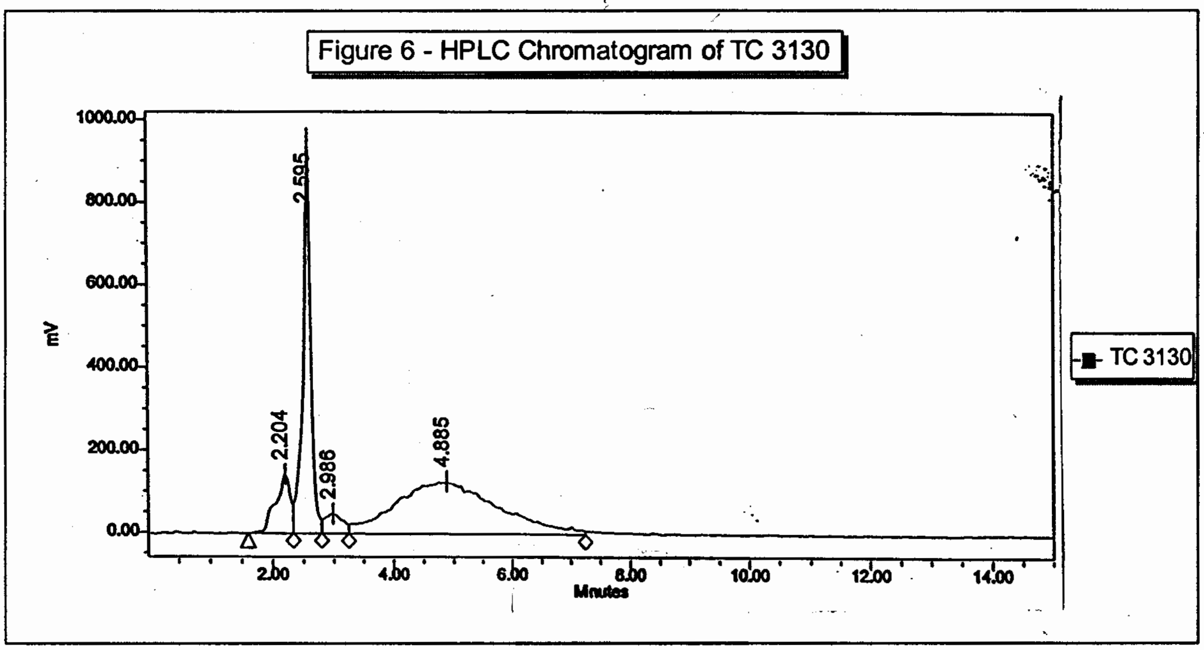


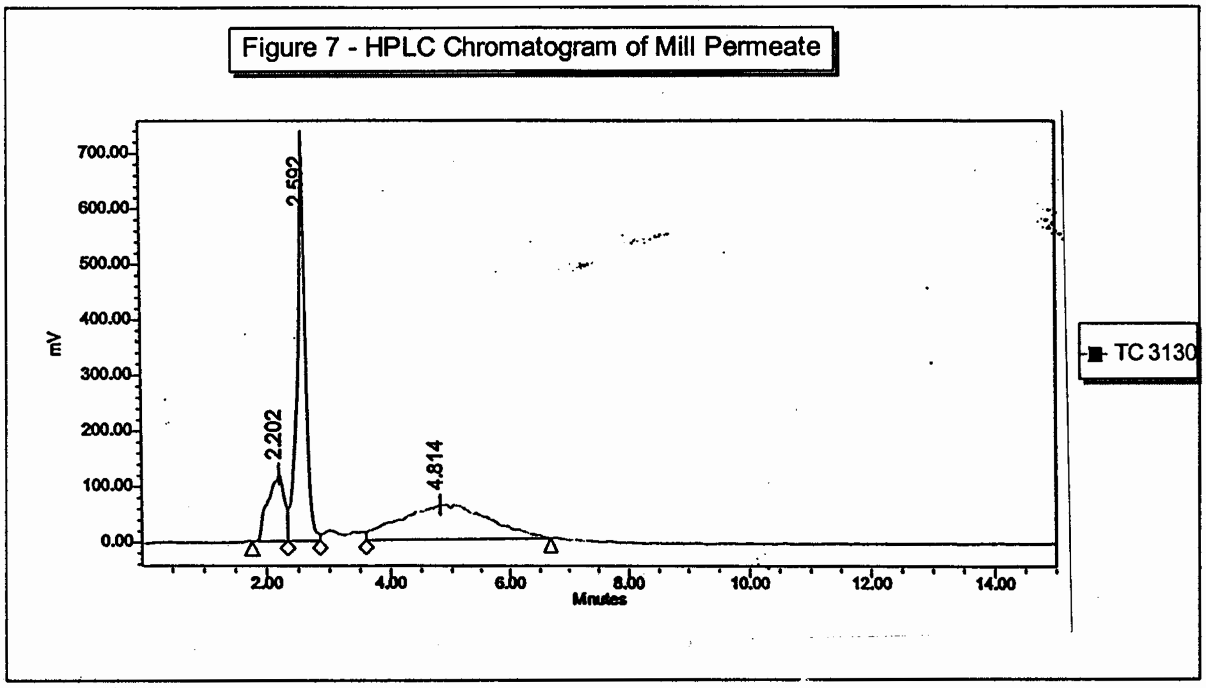
The ultrafiltration system affected total suspended solids (TSS) levels in the feed and permeate streams in much the same way as it affected the oil and grease. Figure 5 shows TSS levels of both the feed and permeate streams. As shown, TSS levels in the permeate were relatively low. TSS levels of the feed ranged from a low of 8,400 mg/L for the combined solution to a high level of 39,000 mg/L in the milling solution. In general, TSS removal ranged from 99.3% to 99.8%.

Table 1: Data Report Summary indicates the various metals level present in the three permeates. It should be noted that while none of the metals exceeded federal or state regulatory limits they should be cross checked with local standards and limits. As indicated in Figure 6, Zinc levels were very high (899 mg/kg) probably due to the amount of galvanized roll stock processed at B-Line.

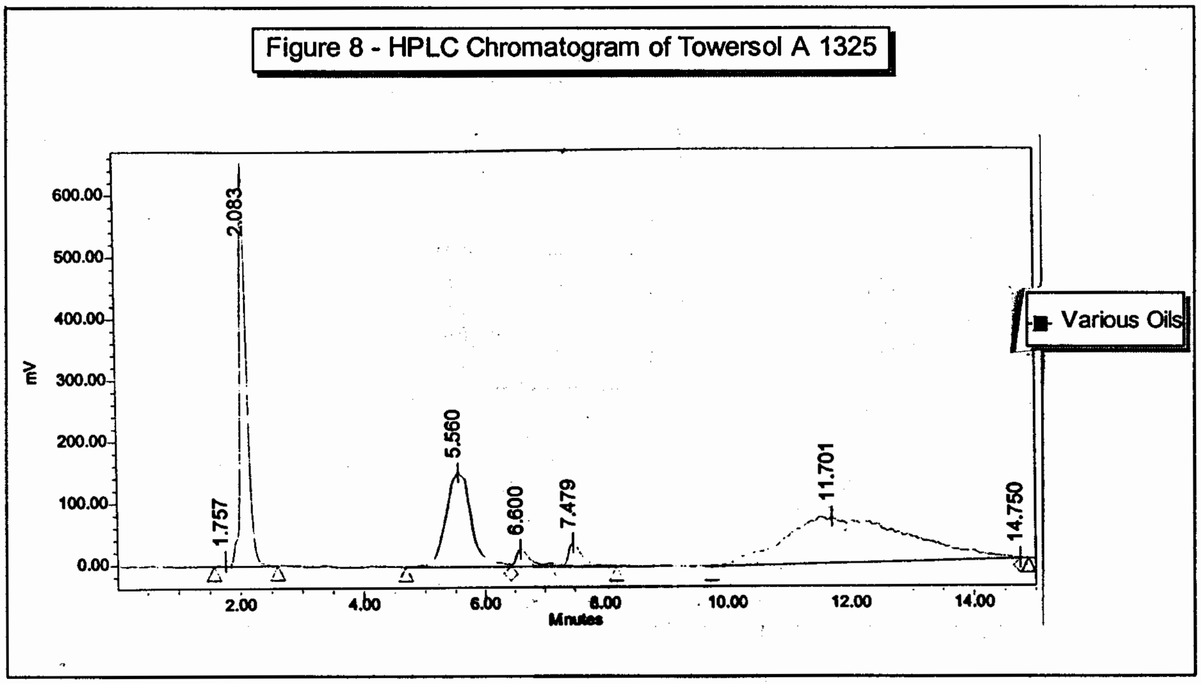


Figures 6 and 7 shows the representative value of recovered TC 3130 present in the permeate of the Milling sample. As indicated by High Pressure Liquid Chromatography (HPLC) data a large portion of the TC 3130 is present in the permeate. The solution contains 18% by volume of the coolant TC 3130 and 82% water. However, part of the nonionic portion of the TC 3130 was removed by the membrane (as indicated by the variance in the third peak of the Mill permeate Chromatogram over the Chromatogram of the virgin TC 3130).





Figures 8 and 9 are also HPLC analyses of the virgin TowerSol A 1325 and the permeate of the feed solution. As indicated by the Chromatogram many of the chemicals seen in the virgin sample have been removed by the membrane rendering the permeate basically water.



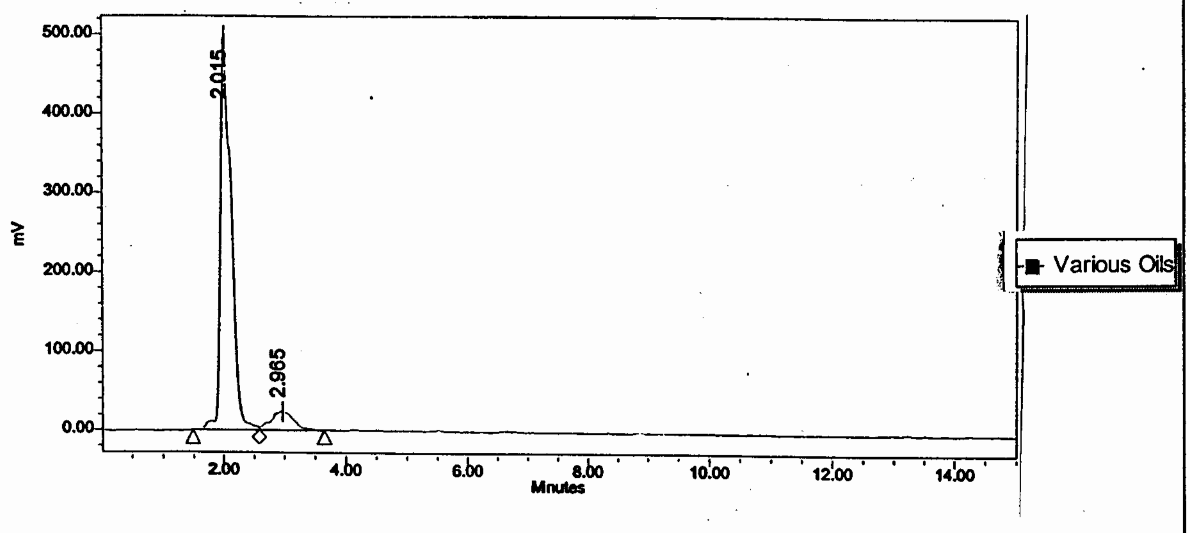


Figure 9 - HPLC Chromatogram of Press Permeate

CONCLUSIONS

Ultrafiltration was successfully demonstrated at B-Line Systems. Not only did the system remove the free and emulsified oils from the oily wastewater as expected but it recovered approximately 90% of the TC 3130. From the data it should be assumed that the oily wastewater could be reduced by approximately 70% and that the permeate produced by the Milling feed solution could be used as make-up in the Milling process.

Also, by placing the membrane system between the flow from the 3M Mill to the oil skimmer B-Line will continue to reduce the oily wastewater, return lost chemicals to the process, and remove contaminants from the coolant.

It should be anticipated that the payback for two membrane filtration systems (one on the Mill side and one on the press side) that would produce approximately 15 gallons of permeate per hour would be less that two years. Table 2 compares the economics and payback of an ultrafiltration system.

REFERENCES

Lindsey, T.C., A.G. Ocker, and G.D. Miller. "Recovery of an Aqueous Iron Phosphating/Degreasing Bath by Ultrafiltration," *Journal of the Air and Waste Management Association.* 1994. 44, 697-701.

Lindsey, T.C. "Evaluation of Ultrafiltration for In-Process Recycling of Cleaning Solution at Ford's Chicago Stamping Plant," TN-98-060. 1997. Illinois Waste Management and Research Center.

Table 1: Data Report Summary

Client: Ken Barnes
Company: B-Line Systems
RSA: 0299-08

Date Submitted: Febrary 11, 1999
Data Completed: February 26, 1999

Quantitated Results

	Client identification	WMRC identification	Arsenic mg/kg	Barium mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Manganese mg/kg	Mercury mg/kg	Nickel mg/kg	Selenium mg/kg	Silver mg/kg	Zinc mg/kg	TSS mg/L	
Mill	99-43KB-02	99-1226	<1	4.6	<1	91	32	2.6	1.5	<0.1	3.8	<1	<1	899	39000	MILL
UF	99-43KB-03	99-1227	0.38	<0.1	<0.1	3.8	5.0	<0.1	<0.1	<0.05	2.5	<0.1	<0.1	72	74	PERMEATE
PRESS	99-43KB-04	99-1228	<1	<1	<1	<1	<1-5.2	<1	2.1	<0.1	<1-34	<1	<1	9.6	3100	PRESS
UF	99-43KB-05	99-1229	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	0.95	7.9	PERMEATE
COMBO	99-43KB-06	99-1230	<1	2.5	<1	48	16	1.0	1.6	<0.1	1.8	<1	<1	447	8400	COMBO
UF	99-43KB-07	99-1231	0.14	<0.1	<0.1	<0.1	1.2	<0.1	0.14	<0.05	<0.1	<0.1	<0.1	24	51	PERMEATE

Semi-Quantitated Results

Client identification	WMRC identification	Antimony mg/kg	Tin mg/kg	Iron mg/kg
99-43KB-02	99-1226	2.7	4.5	16
99-43KB-03	99-1227	1.9	0.8	2.5
99-43KB-04	99-1228	<1	<1	8.2
99-43KB-05	99-1229	<0.1	<0.1	<0.1
99-43KB-06	99-1230	1.5	2.2	12
99-43KB-07	99-1231	0.8	0.3	1.9

Analyst: Luann Wiedemann 3-2-99

Group Leader: Jonathan Talbott 3-2-99

Analyst:

Group Leader: [illegible] 3-3-99

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Table 2 - B-Line Membrane Filtration Installation Economic Feasibility

Present Costs **

Item	Cost	Quantity	Frequency	Total Cost
TC 3130 Milling Coolant	$10.00	6,000	Annual	$60,000.00
Mill Filters	$14.00	936	Annual	$13,104.00
Water	-	-	Annual	n/a
Cleaning (tank/sump)*	$20.00	10	26 wks	$5,200.00
Re-charge labor*	$20.00	4	26 wks	$2,080.00
Oily Waste Disposal	$0.62	30,000	Annual	$18,600.00
Present Operational Cost				**$98,984.00**

*Proposed Costs***

TC 3130	$10.00	600	Annual	$6,000.00
Mill Filters	$14.00	936	Annual	$13,104.00
Water	-	-	Annual	n/a
Cleaning*	$20.00	10	13 wks	$2,600.00
Re-charge labor*	$20.00	4	13 wks	$1,040.00
Oily Waste Disposal	$0.62	9,000	Annual	$5,580.00
Electricity (kwh)*	$0.10	24	365 days	$876.00
Maintenance*	$20.00	2	24 wks	$960.00
Membrane Replacement*	$400.00	4	3 years	$533.00
Proposed Operational Cost				**$30,693.00**
Savings*				**$68,291.00**

*Capital Investments***

Mill Membrane System (15 gph)	$25,000.00	1	-	$25,000.00
Press Membrane System (15 gph)	$25,000.00	1	-	$25,000.00
Installation labor	$20.00	40	-	$800.00
Installation piping	$1,000.00	1	n/a	$1,000.00
Back-up membranes	400	4	n/a	$1,600.00
Installation wiring	$20.00	40	-	$800.00
Miscellaneous	$1,000.00	1	-	$1,000.00
Total Capital Cost				**$55,200.00**

Simple Payback

Capital Cost/Saving*	**10 Months**

* Estimated cost
** Based on known quantities and costs