Centrifugal Membrane Filtration - Task 9

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CENTRIFUGAL MEMBRANE FILTRATION

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC) has teamed with SpinTek Membrane Systems, Inc., the developer of a centrifugal membrane filtration technology, to demonstrate applications for the SpinTek technology within the U.S. Department of Energy (DOE) Environmental Management (EM) Program. The EERC is providing both assessment opportunities based on available information on wastes in the DOE inventory and focused testing to demonstrate the effectiveness of the SpinTek technology on selected waste streams. The technology uses supported microporous membranes rotating at high rpm, under pressure, to separate suspended and colloidal solids from liquid streams, yielding a solids-free permeate stream and a highly concentrated solids stream. This is a crosscutting technology that falls under the Efficient Separations and Processing Crosscutting Program, with potential application to tank wastes, contaminated groundwater, landfill leachate, and secondary liquid waste streams from other remediation processes, including decontamination and decommissioning systems. Based on the EERC's review of potential applications, the Tank Waste Focus Area was chosen for focused study.

Membrane-screening tests were performed with the SpinTek STC-X4 static test cell filtration unit, using five ceramic membranes with different pore size and composition. Based on permeate flux, a 0.25- μm $\text{TiO}_2/\text{Al}_2\text{O}_3$ membrane was selected for detailed performance evaluation using the SpinTek ST-IIL centrifugal membrane filtration unit with a surrogate tank waste solution.

The performance of the ST-IIL centrifugal membrane filtration unit was evaluated using a statistical test design that determined the effect of four key operating parameters (temperature, pressure, membrane rotational speed, and solids loading) on permeate flux. All four variables were found to be statistically significant, with the magnitude of the effect in the order of temperature, solids loading, rotor speed, and pressure. Temperature, rotor speed, and pressure had an increasing effect on flux with increasing value, while increases in solids loading showed a decrease in permeate flux. Significant interactions between rotor speed and solids loading and pressure and solids loading were also observed. The regression equation derived from the test data had a correlation coefficient (R^2) of 0.934, which represents a useful predictive capability for integrating the SpinTek technology into DOE cleanup efforts. An extended test run of 100 hr performed on a surrogate tank waste solution showed some deterioration in filtration performance, based on flux, apparently due to the buildup of solids near the inner portion of the membrane where relative membrane velocities were low. Continued testing of the system will focus on modifications to the shear pattern across the entire membrane surface to affect improved long-term performance.

CENTRIFUGAL MEMBRANE FILTRATION

1.0 INTRODUCTION

Approximately 90% of all the mixed, hazardous, and radioactive waste that has ever been generated in the United States has come from U.S. Department of Energy (DOE) installations. To compound the problem, the wastes were generated during the Cold War, when the race to develop nuclear weapons did not factor in environmental considerations. Environmental disposal was common and was believed to have limited long-term implications; however, many of the chemical constituents in the wastes are now known or suspected to pose significant human and environmental health concerns and are regulated under federal and state statutes. Fifty years of nuclear armament have produced spent nuclear fuel, more than 3000 inactive waste sites, an estimated 3.1 MM m³ of buried waste, deteriorating high-level nuclear waste storage tanks, and a public questioning DOE's commitment and ability to correct the problems. The total cost of environmental compliance and cleanup at the 18 DOE facilities are estimated at approximately \$60 to \$90 billion (1, 2).

Recognizing the severity of environmental problems at its facilities, DOE has begun to remediate its contaminated sites. As part of these remediation efforts, basic research has been funded to improve the understanding of contaminant transport and fate and develop new and more appropriate remediation options.

The extent and complexity of contamination vary among the DOE sites according to the facility mission, size, and waste management practices. Even though many waste sites have been identified, the extent and complexity of the contamination are still largely unknown. The larger DOE facilities typically had multiple activities, which were chemically intensive, producing subsurface contamination of an extremely complex nature. The smaller facilities were more limited in their activities, resulting in less complex subsurface contamination. Contamination levels at the evaluated sites range from low levels of parts per billion (ppb) for certain chemicals to elevated levels, as high as parts per hundred (pph), for other constituents.

Environmental media are contaminated with radionuclides, metals, and anions. Other contaminants include chlorinated solvents, fuel hydrocarbons, plasticizers, polychlorinated biphenyls (PCBs), explosives, organic acids, pesticides, and pharmaceutical wastes. Concentrations of radionuclides in groundwater have been reported in the range of picocuries per liter (pCi/L) up to millicuries per liter (mCi/L).

The DOE Environmental Management (EM) Program, formerly known as the Office of Environmental Restoration and Waste Management, was created in November 1989 to initiate the management and remediation of contamination problems at several DOE facilities used in the research and production of nuclear arms and fuels over a period of nearly 50 years. These facilities contain 3700 specific sites with over 26,000 acres of hazardous or radioactive contaminated soils, groundwater, and structures. The EM mission is to minimize risks to the environment, human health, and safety posed by the production, handling, treatment, storage, transportation, and disposal of DOE waste and to bring DOE sites into compliance with all environmental regulations by the year 2019.

Within the EM Program is the Office of Science and Technology, formerly called the Office of Technology Development, which is responsible for developing technologies to meet DOE's 30-year goal for environmental restoration. This program is designed to identify and develop innovative and cost-effective technologies that can clean up the inventory of DOE nuclear component-manufacturing sites and manage DOE-generated waste faster, safer, and more cost-effectively than is possible with current environmental cleanup technologies.

To achieve the EM objectives, there are five main focus areas within the EM Program, which are divided into several subprograms. These main focus areas are as follows:

- Contaminant Plumes Containment and Remediation
- Mixed-Waste Characterization, Treatment, and Disposal
- Radioactive Tank Waste Remediation
- Landfill Stabilization
- Decontamination and Decommissioning

The subprograms of these focus areas are in place to further concentrate similar efforts and promote and develop promising technologies. Together with private, federal, and state facilities, the EM Program hopes to provide visibility, focus, and accountability for DOE's waste management and cleanup efforts.

SpinTek Membrane Systems, Inc., has developed a novel centrifugal membrane filtration process that has application in remediation efforts currently under way at the various contaminated DOE sites. The greatest benefits of centrifugal membrane ultrafiltration include its efficient separations, efficient processing, and high-rate volume reduction capabilities. The innovative membrane filtration system coupled with centrifugal force gives this crosscutting technology distinct advantages over conventional ultrafiltration processes. It can accept feed streams containing relatively large particulate sizes, unlike hollow fiber ultrafilters, and can maintain high permeate flux at significantly higher feed solids concentrations than tubular or spirally wound ultrafiltration units. Rotating membrane ultrafiltration could be one step in a series of remediation operations or employed in series using multiple membrane types to selectively remove various waste components. Used as a stand-alone unit, it is capable of producing a permeate free of colloidal and suspended solids and a low-volume concentrate stream. The SpinTek technology may also be used as a complement to other cleanup efforts.

2.0 OBJECTIVES

This project consists of several integrated research phases related to the applicability, continued development, demonstration, and commercialization of the SpinTek centrifugal membrane filtration process for the remediation of liquid mixed-waste streams at DOE facilities. Specific Phase I project objectives include the following:

- A problem and opportunity assessment to identify applicable waste streams, including mixed wastes, associated with DOE sites

- Development of detailed process data that will provide information on the application of the technology at DOE sites
- Testing and evaluation of a laboratory centrifugal membrane filtration unit using surrogate waste streams under a variety of operating conditions
- Development of process data that will allow optimization of the technology for appropriate DOE waste stream remediation

3.0 SPINTEK CENTRIFUGAL MEMBRANE FILTRATION

The SpinTek centrifugal membrane filtration process is designed to accomplish difficult separations under harsh conditions in a cost-effective manner. Using ultrafiltration membranes, the process separates suspended solids down to about 1000 molecular weight (MW). With reverse-osmosis membranes, suspended solids smaller than 1000 MW can be removed along with 96%–98% of dissolved solids. General applications for the system range from removing undesirable contaminants to concentration for recovery of solids or dissolved species. The feed stream to the filtration system is divided into two output streams, the permeate and the concentrate, with the permeate making up about 75%–95% of the effluent. Either the permeate or concentrate can be the desired end product, depending upon the application.

During ultrafiltration or reverse osmosis, liquid is forced through a semipermeable membrane, leaving suspended and dissolved solids larger than the nominal membrane pore size at the membrane interface. Therefore, the concentration of solids at the boundary between the membrane and the feed solution is increased. This phenomenon is referred to as concentration polarization, and the result is decreased flow through the membrane because of fouling. Traditional systems attempt to solve the problem of concentration polarization through the use of turbulence promoters or high recycle flow rates to remix the concentrated solution. However, these methods lose effectiveness with significant increases in solids concentration.

Research on concentration polarization phenomenon revealed that water flow and salt rejection both increased when a reverse-osmosis membrane was operated while centrifugal acceleration was applied parallel to the membrane–liquid interface. The SpinTek system takes advantage of these process dynamics. Disk-shaped membrane packs are stacked on a hollow rotor inside of a cylindrical housing. The rotor spins at speeds of up to 3500 rpm to develop centrifugal forces exceeding 400 times the force of gravity across the membrane surfaces. Static turbulence promoters are located on either side of each membrane pack to impart shear forces to the concentrated boundary layer. Feed water enters through the cylindrical housing and is forced to flow across the filters. A back-pressure regulator/control valve is used to provide up to 150 psig inside the pressure vessel, which is the driving force for the movement of product water through the membranes. Permeate is forced to the central hollow rotary shaft, which acts as the main permeate collector, and flows out of the membrane housing. Salts and solids left concentrated at the membrane surface are kept in suspension through turbulent shear and are swept to the perimeter of the disks by centrifugal force. The concentrate stream then exits the membrane housing and can be collected separately or recycled for additional concentration. A schematic of the basic SpinTek

centrifugal membrane filtration system, showing a cutaway of a single membrane pack, is given in Figure 1.

Each membrane pack consists of a rigid internal support plate, with microfiltration membranes covering both sides. The membranes are separated from the support plate by a highly permeable layer of polypropylene mesh or similar type of material. Either membrane type can be used, depending on system design criteria. Since the membranes are flat, high-tech construction materials such as metal and ceramics may be used, as well as traditional cellulosic and polymeric formulations. Essentially, the system can be configured to utilize any commercially available flat-sheet membrane. The membrane packs are stacked together to provide high packing density. The capacity of the unit depends on the number of packs and the height of the pressure vessel. Capacity can be increased or decreased by adding or subtracting packs.

The system operates well in high-fouling environments that would be unsuitable for conventional membrane systems operated in a static mode. To date, successful on-site testing has been performed on fermentation and food-processing streams and on process streams containing clays, colloids, and industrial oils. Specific examples of SpinTek system successes include recovery of latex from a dilute waste stream (1% solids) and concentration up to 50%; concentration of hydrated alumina to 40%; yeast concentration above 35%; and 90+ % recovery of protein from cheese whey. The centrifugal membrane filtration system has also been shown to be effective in concentrating nonsettleable solids to viscosities above 6400 centipoise.

SpinTek's rotating membrane is superior to traditional units because of its low fouling tendencies and increased flow characteristics. However, the membrane species used will require

Figure 1. Schematic representation of the SpinTek centrifugal membrane filtration system showing a single membrane pack.

evaluation for each waste stream to optimize product water flux. A wide range of membrane types can be utilized in the SpinTek system, with both hydrophilic and hydrophobic polymeric membrane types available, as well as membranes that show excellent resistance to solvents. Table 1 lists the various types of membranes that have been tested in the SpinTek system. These membranes are durable, industrial-grade membranes with unique characteristics that make them more or less suitable for various applications. Brief descriptions of each membrane's properties are included in the table.

4.0 SPINTEK CENTRIFUGAL MEMBRANE FILTRATION TESTING PROGRAM

4.1 Waste Stream Selection

A literature review was conducted to assess the liquid waste stream problem at DOE facilities and to identify potential applications of the SpinTek technology. An interim project report was prepared and is included as Appendix A. Based on that review, centrifugal membrane filtration was classified as a crosscutting technology that has potential application in all five DOE EM Program focus areas. For this study, the Radioactive Tank Waste Remediation Focus Area was selected for SpinTek testing and evaluation.

There are 332 underground storage tanks across the DOE complex accounting for 100 million gallons of radioactive wastes. The composition of the tank wastes varies, but typically contains nitrate and nitrate salts, hydrated metal oxides, phosphate precipitates, ferrocyanides, and radionuclides, such as ^{90}Sr and ^{137}Cs . These wastes exist as three physical forms, both individually and in combination: liquid supernatant, sludge, and hard salt cake.

The SpinTek centrifugal membrane filtration process has several potential applications for the remediation of tank wastes, providing an effective means of waste separation and waste volume reduction, while producing a solids-free effluent that will improve the operation and efficiency of downstream unit operations for cesium and strontium removal. Figure 2 shows a schematic representation of these applications. The upper portion of the Figure 2 diagram illustrates the direct filtration of colloidal and suspended solids from tank waste supernatants, while the lower portion of the figure depicts its use in dewatering and solids concentration in conjunction with tank sludge-washing operations. Additionally, the SpinTek process could be used in conjunction with salt cake removal operations, such as "confined sluicing" where the permeate stream could be recycled back to the sluicing system, reducing the need for additional makeup water.

Table 2 provides a list of the surrogate chemicals and their respective concentrations that were used to simulate tank wastes during the centrifugal membrane filtration test trials. This particular solution represents the major contaminants in INEL (Idaho National Engineering Laboratory) high-sodium tank wastes.

In order to simulate the solids or sludge from tank wastes, a suspension of kaolin was added to the surrogate solution. This application of SpinTek centrifugal membrane filtration, then, was designed to demonstrate the efficient removal of suspended and colloidal solids in the supernatant, as well as solids separation during sludge and salt cake removal and washing operations.

TABLE 1

Membranes Available for the SpinTek Centrifugal Membrane Filtration System	
Polyvinylidene Fluoride (PVDF)	Excellent general-purpose membrane available in a variety of pore sizes that generally exhibits very good clean water fluxes. Resists biological attack; moderate pH and temperature limitations; moderately hydrophobic.
Polysulfone (PS)	Good general-purpose membrane with good clean water fluxes and in some cases greater chemical resistance than PVDF. Resists biological attack; moderate pH and temperature limitations; moderately hydrophilic.
Polyethersulfone (PES)	Exhibits many of the same characteristics as the PS membrane but has greater chemical resistance. Resistant to higher levels of oxidizing agents such as chlorine, certain aliphatic hydrocarbons, and alcohol.
Hydrophilic Polyethersulfone (HPES)	Membrane specially formulated to be highly hydrophilic. Should only be used when normal PS or PES membranes perform marginally.
Polyester (PETE)	Track-etched membrane that is hydrophilic and has excellent chemical resistance to most commonly used chemicals. The most acid-resistant of commonly used membranes, but susceptible to attack by strong bases.
Polycarbonate (PC)	Track-etched membrane with poorer solvent resistance than PETE. Free of extractables and available in a wide range of pore sizes.
Polyolefin (PO)	Very hydrophilic and most suited to oily water separations. More stringent temperature limitations with respect to most other polymeric membranes. Available pore sizes limited to the ultrafiltration range.
Polyimide (PI)	Very solvent-resistant, but available only in limited pore sizes. Should be considered in many hydrocarbon and solvent applications.
Polyaramide (PA)	Excellent solvent resistance. However, permeate rates are generally lower than several other membrane types. Available pore sizes are limited to the ultrafiltration range.

continued . . .

TABLE 1 (continued)

Membranes Available for the SpinTek Centrifugal Membrane Filtration System	
Teflon (PTFE)	Excellent clean water fluxes and chemical resistance. Current membrane formulations are very hydrophobic, with more hydrophilic versions to be available in the future. Weak mechanical strength makes membrane highly susceptible to damage. Therefore, PTFE should be selected only when its exceptional chemical resistance overrides the structural shortcomings.
Ceramic (CR)	Available in formulations with exceptional resistance to solvents and temperature extremes. Very rugged and less susceptible to irreversible fouling because of the range of cleaning compounds that can be utilized for flux recovery.
Stainless Steel (SS)	Sintered 316 SS construction. Chemically resistant with extremely high clean water fluxes. Impervious to biological attack, with excellent pH and temperature resistance. Membrane has a tendency to trap particles within the metal matrix and hence lose flux quickly.

EERC DS12518.CDR

Figure 2. Schematic representation of SpinTek applications in the Tank Waste Focus Area.

TABLE 2

Surrogate Tank Waste Composition	
Component	Concentration, mol/L
NaNO ₃	1.78
HNO ₃	1.66
KNO ₃	0.23
Ca(NO ₃) ₂	0.04
H ₂ SO ₄	0.03
Fe(NO ₃) ₃	0.03
H ₃ BO ₃	0.02
HCl	0.02
H ₃ PO ₄	0.01
Mn(NO ₃) ₂	0.01
Al(NO ₃) ₃	0.004
Cd(NO ₃) ₂	0.002
Ni(NO ₃) ₂	0.002
Hg(NO ₃) ₂	0.002
CsNO ₃	0.00004
Sr(NO ₃) ₂	0.000029

4.2 Membrane Screening and Selection

SpinTek has a small test unit available with the capability to test up to four membrane types simultaneously at the same conditions on a given feed stream. This test unit, designated the STC-X4, makes use of static membrane cells in which the feed material flows past small sections of membrane (approximately 3 in. $\times$ 4.5 in.) at velocities of up to about 15 fps. Feed material enters each cell and flows through a channel in a serpentine path to the cell exit. The flow channel is 0.312 in. wide and 0.100 in. deep. The total membrane area in which filtration takes place is 0.0493 ft². Using the STC-X4, many different membrane types, such as those listed in Table 1, can be quickly evaluated in terms of permeate flux, permeate quality, and membrane durability. Any flat-sheet membrane material available can be utilized. The results of STC-X4 testing can then be used to scale up to SpinTek's ST-IIL rotating membrane test unit.

Prior to testing and performance evaluation using the ST-IIL centrifugal membrane filtration unit, membrane-screening trials were conducted using SpinTek's STC-X4 test unit. Because of the nature of the tank wastes, ceramic membranes were considered for screening. Five ceramic membranes having different mean pore sizes and different compositions were evaluated during the screening trials:

- 0.25- μ m TiO₂/Al₂O₃
- 0.25- μ m TiO₂/SiO₂
- 0.3- μ m ZrO₂/TiO₂
- 0.4- μ m TiO₂/Al₂O₃
- 0.6- μ m ZrO₂

Membrane-screening activities involved testing of the various membranes under several different operating conditions of pressure and solids loading. Temperature and flow rates were held constant throughout all screening tests at 90°F and 1 gallon per minute, respectively. Feed pressures were varied between 30 and 75 psig. Two different solids loadings, 0 and 3 wt%, were evaluated.

Table 3 summarizes screening test results using the surrogate tank waste solution with no solids added. In general, all five different membranes exhibited an increase in flux with increasing feed pressure. Additionally, membranes with a larger nominal pore size had a greater flux.

The second set of membrane-screening trials was conducted using the surrogate tank waste solution with 3 wt% kaolin added. Table 4 summarizes test results with the 3 wt% surrogate tank waste solution at an average feed pressure of 29.5 psig. Performance, as measured by flux, was observed to be higher than test trials under similar pressure conditions with no added solids. The reason for this is not clearly understood, as one would intuitively think that additional solids would reduce flux. It is noteworthy, however, that flux did not show an increase with increasing nominal pore size, apparently due to plugging of the larger diameter pores, thus reducing overall filtration capacity. Test data collected during membrane screening and selection activities are presented in Appendix B.

Based on a review of the data by SpinTek and EERC personnel, it was decided that a smaller diameter pore size membrane would be used for performance evaluation using the SpinTek ST-III unit. A 0.25- μm $\text{TiO}_2/\text{Al}_2\text{O}_3$ ceramic membrane was ultimately selected because of performance and availability.

TABLE 3

Membrane Screening Results - Surrogate Tank Waste Solution with No Added Solids					
Membrane:	$\text{TiO}_2/\text{Al}_2\text{O}_3$	$\text{TiO}_2/\text{SiO}_2$	$\text{ZrO}_2/\text{TiO}_2$	$\text{TiO}_2/\text{Al}_2\text{O}_3$	ZrO_2
Pore Size:	0.25 μm	0.25 μm	0.3 μm	0.4 μm	0.6 μm
Average Feed Pressure, psig	28.4	28.4	28.4	28.5	28.5
Average Concentrate Pressure, psig	6.6	6.6	6.6	5.6	5.6
Average Measured Flux, gal/ft ² -day	63.8	69.0	63.1	57.1	60.7
Average Feed Pressure, psig	46.9	46.9	46.9	- ^a	-
Average Concentrate Pressure, psig	14.6	14.6	14.6	-	-
Average Measured Flux, gal/ft ² -day	72.3	75.0	82.0	-	-
Average Feed Pressure, psig	72.5	72.5	72.5	72.9	72.9
Average Concentrate Pressure, psig	39.9	39.9	39.9	39.1	39.1
Average Measured Flux, gal/ft ² -day	143.3	145.6	149.3	200.1	207.6

^a Not performed.

TABLE 4

Membrane Screening Results – Surrogate Tank Waste Solution with 3 wt% Kaolin Added					
Membrane:	TiO ₂ /Al ₂ O ₃	TiO ₂ /SiO ₂	ZrO ₂ /TiO ₂	TiO ₂ /Al ₂ O ₃	ZrO ₂
Pore Size:	0.25 μ m	0.25 μ m	0.3 μ m	0.4 μ m	0.6 μ m
Average Feed Pressure, psig	29.9	29.9	29.9	29.2	29.2
Average Concentrate Pressure, psig	7.0	7.0	7.0	6.0	6.0
Average Measured Flux, gal/ft ² -day	100.0	104.9	96.3	82.3	79.0

4.3 Centrifugal Membrane Filtration Performance Evaluation

Performance evaluation of the centrifugal membrane filtration process was conducted using the 0.25- μ m TiO₂/Al₂O₃ ceramic membrane on the SpinTek ST-IIL unit. Based upon preliminary process evaluation, four key factors—temperature, pressure, rotor speed, and solids loading—were identified as having the greatest potential influence on process performance, as measured by flux. An experimental test plan was designed to account for statistically significant interactions of the variables and the determination of optimized operating conditions for treating tank wastes. Table 5 shows the coded design set point operating conditions selected to determine process performance and develop statistical data. Based on the optimized operating condition, an extended run was conducted to determine performance over time. The following discusses the methodology and results of this testing.

A schematic diagram of the ST-IIL process, as configured for testing and evaluation, is shown in Figure 3. The surrogate tank waste solution for a designated test was placed in the surge tank, and the mixer was turned on to maintain the solids in suspension. The feed pump was turned on, and flow was established at 132 gallons per hr for each test run. The pressure controller was then set to the desired pressure for the run. When the desired pressure was obtained, the rotor motor was turned on and set to the desired rpm. The system was then allowed to equilibrate at the desired temperature setting. Each experimental run was conducted over a 3- to 4-hr period after set point operating conditions had been established. When steady-state flux was achieved, data were collected over a 2-hr period. Operating data for each of the 27 test runs are provided in Appendix C.

TABLE 5

Selected Operating Conditions			
Parameter	Test Condition Set Point		
	Lower (-1)	Midpoint (0)	Upper (+1)
Temperature, °F	60	90	120
Pressure, psig	45	60	75
Rotor Speed, rpm	1000	1500	2000
Solids Loading, wt%	1	15	30

Figure 3. SpinTek ST-III process schematic.

4.3.1 Experimental Design

In order to determine the effects of temperature, feed pressure, rotor speed, and solids concentration, a statistically designed experimental matrix was created that would test the significance of these variables and also result in an empirical model of the observed response. The simplest design is a full-factorial matrix that requires approximately 20 experiments to formulate a linear model. However, a response surface model using a Box-Behnken design requires only 27 experiments, but affords all of the benefits of a quadratic model to fit the experimental data. The latter design is more efficient in the event that one of the experimental variables results in a nonlinear response and was used for constructing the test matrix used in this study. The advantage of using a statistical design is that the levels of the variables are chosen to maintain the independence of their effects on the response or, alternatively speaking, the variables are uncorrelated with each other.

4.3.2 Statistical Analysis of Data

The actual uncoded independent and dependent variables are summarized in Table 6 for each of the 27 tests performed using the Box-Behnken design. Note that the experiments were randomized prior to execution to remove the effect of bias from the analysis, and the time reflects the cumulative run time based on the randomized order. The average steady-state data shown in Table 6 were modeled using the multiple linear regression procedure (REG) from the SAS/STAT™ statistical software package to determine the significant variables and regression coefficients. As part of the analysis, all independent variables were coded to normalize the range of values between -1 and 1. The normalization of the data allows one to examine the regression coefficients for their relative contribution to the model.

TABLE 6

Test Conditions and Measured Data from Experimental Test Matrix

Test	Rotor Speed, rpm	Pressure, psig	Solids, %	Temperature, °F	Flux, gfd	Std. Dev., gfd	Time, hr
1	1991	44	15	90	316	14.4	3.32
2	1501	75	15	119	427	16.3	5.65
3	995	61	1	90	528	16.7	9.2
4	1991	60	30	90	254	14.4	12.22
5	986	45	15	90	193	4.0	15.14
6	1498	74	1	89	488	11.0	19.12
7	2008	61	1	89	526	12.2	22.64
8	1491	60	30	119	259	15.2	25.11
9	1501	47	30	89	184	7.3	28.29
10	1500	62	1	120	604	20.8	31.47
11	993	58	30	89	90	9.8	34.62
12	1499	77	30	90	155	12.5	37.67
13	1503	61	15	90	218	10.9	40.85
14	998	59	15	120	221	10.3	44.07
15	1499	61	30	59	114	11.5	48.09
16	1512	59	15	90	209	8.9	51.11
17	997	57	15	60	92	2.3	55.13
18	995	78	15	89	160	3.3	58.7
19	1499	59	15	90	200	10.5	61.13
20	1501	43	15	60	114	1.1	63.53
21	1498	59	1	61	140	1.8	66.03
22	2015	73	15	90	329	18.2	69.1
23	1994	63	15	120	408	23.2	72.38
24	1507	47	15	120	299	12.5	75.7
25	1501	71	15	60	162	5.4	78.45
26	1487	45	1	89	193	5.7	81.07
27	2005	57	15	60	180	3.5	84.05

In order to make value judgments on the significance of the variables in a model through statistical inference, certain criteria must be met. Among these are that the form of the model is correct, that the variance among the observations of the dependent variable (flux) are constant, and that the errors are normally distributed. These criteria can also be interrelated. For example, if the form of the model is incorrect or the variance of the observations is not a constant, then the errors may not be normally distributed. The objective of the modeling effort is, therefore, to meet these criteria by selecting the best form of the model by transforming the data.

Figure 4 shows a plot of the standard deviation as a function of the permeate flux (response variable). As mentioned previously, the variance of the data should be constant across all

Figure 4. Standard deviation as a function of flux.

observations; however, the figure clearly shows a trend of increasing variance with flux rate. This trend was shown to be statistically significant, with only a 1-in-10,000 chance of the slope of the line actually being zero. On the other hand, Figure 5 presents the relative standard deviation (RSD) as a function of the flux and shows the independence of the RSD with flux. The RSD is the standard deviation divided by the mean and puts the data variation on a percent, rather than an absolute, basis. In the case of Figure 5, there is a 29% probability that the slope is equal to zero; therefore, the slope is very likely to be zero.

To meet the criteria of constant variance as depicted in Figure 5, the data must be transformed. This can be accomplished by taking the logarithm of the response variable (flux); i.e., the standard deviation expressed on a log scale is equivalent to the RSD on a linear scale. Because of the logarithmic transformation, the resultant model will be exponential and of the form $y=ab^x$, where a and b are constants calculated from the linear regression.

A summary of the statistics for the best-fit linear regression model is presented in Table 7. As seen from Table 7, all of the variables included in the test matrix were significant at 95% probability or better, and in addition, there were interactions among the parameters of rotor speed and solids concentration and feed pressure and solids concentration.

The magnitude of the parameter estimates (coefficients used to formulate the modeling equation) indicate that the influence of the variables follows the order:

$$\text{Temperature} \geq \text{Solids Concentration} > \text{Rotor Speed} > \text{Pressure}$$

Figure 5. Constant variance criteria transformation for statistical model.

TABLE 7

Summary of Model Statistics for Predicting the Logarithm of Permeate Flux
Dependent Variable: $\log(\text{flux})$

Variable	DF	Parameter Estimates			
		Parameter Estimate	Standard Error	T for H0 Parameter = 0	Prob. > T
Intercept	1	2.356882	0.01346299	175.064	0.0001
rpm	1	0.144016	0.02073814	6.944	0.0001
Pressure	1	0.057948	0.02361105	2.454	0.0239
Solids	1	-0.179544	0.02028288	-8.852	0.0001
Temperature	1	0.180538	0.02185245	8.262	0.0001
rpm × Solids	1	0.090153	0.03619734	2.491	0.0222
Pressure × Solids	1	-0.093287	0.04307829	-2.166	0.0433
Time	1	-0.103791	0.02498318	-4.154	0.0005

The sign of the coefficients also indicates that an increase in pressure, rotor speed, or temperature will result in an increase in the permeate flux, while increasing the solids concentration will tend to decrease the flux. The interaction terms show that the level of one variable in the interaction will impact the effect of the other; e.g., the change in the flux of the permeate with rpm will be different at a low solids concentration than at a high solids concentration. The cumulative run time variable was introduced into the model after discovering the membrane flux had

diminished as a result of running the 27 experiments. This variable was found to be very significant, illustrating that other variables such as chemical or physical erosion or membrane plugging had occurred in a manner that was time-dependent.

Figure 6 shows a plot of the residuals, the difference between the actual values and those predicted by the statistically derived model, as a function of normal probability. The straight-line plot shows that the errors are normally distributed, required for applying statistical inference, and indicates that the logarithmic transformation of the data was adequate. The points at both ends of the line may be outliers to the data set and correspond to Tests 3 and 21 in the test matrix shown in Table 6. These two points share a common element of being at the lowest solids concentration of 1%. If these data points are valid, then this could indicate that the flux is sensitive to the region near 0% solids concentration and that these concentrations need to be measured more accurately to be modeled correctly, e.g., 0.55% solids instead of 1%.

Figure 7 presents a plot of the actual log(flux) versus the predicted log(flux) for the best-fit model shown in Table 7. The correlation coefficient (R^2) for the predictive model was 0.934, with the 45 degree line representing a perfect fit of an R^2 equal to 1. An equivalent plot is shown in Figure 8, where the inverse logarithms were used to convert the data to more meaningful units.

The predictive equation presented in Table 7 is in the coded form and is not readily solvable by direct substitution of values from Table 6 for the independent variables. After substituting in the independent-variable-coding equations, multiplying and collecting terms, the functional form of the modeling equation becomes:

$$\log(\text{flux}) = 1.448 + 9.270\text{E-}5 (\text{rpm}) + 8.999\text{E-}3 (P) - 8.310\text{E-}3 (S) + 5.918\text{E-}3 (T) \quad [\text{Eq. 1}] \\ + 1.208\text{E-}5 (\text{rpm})(S) - 3.670\text{E-}4 (P)(S) - 2.572\text{E-}3 (t)$$

where

rpm = rotor speed, rpm
P = feed pressure, psig
S = solids concentration, %
T = temperature, °F
t = cumulative run time, hr

Because all of the coefficients are small, further simplification by taking the inverse logarithm of Equation 1 will result in loss of accuracy unless the coefficients are carried out to 7 or more significant figures. The exponential form of Equation 1 then becomes

$$\text{Flux} = 28.05 (1.0002135)^{\text{rpm}} (1.02094)^P (0.98105)^S (1.01372)^T (1.00002782)^{\text{rpm} \cdot S} \quad [\text{Eq. 2}] \\ (0.99916)^{PS} (0.99409)^t$$

Equation 2 allows for direct substitution of operating parameters into the exponents to calculate a flux rate, but Equation 1 is more accurate and practical to apply. It should be noted that extrapolation of this model beyond the limits of the experimental range should be avoided, since the results are unpredictable.

Figure 6. Plot of residuals.

Figure 7. Log of measured flux versus log of predicted flux.

Figure 8. Measured versus predicted flux.

4.3.3 Surface Plots for Predictive Equation

Surface plots provide a convenient means of examining the model graphically. These plots were generated from the statistical model characterizing the experimental data. The coded version of Equation 2 was used to plot the response surfaces for the variables in the model because of greater accuracy and simplicity in solving the equation. In the coded format, a +1 is the greatest value of the experimental range, 0 is the midpoint, and -1 is the smallest value. For example, a nominal rotor speed of 2000 rpm equals +1, while 1000 rpm is equal to -1. Since there were six dimensions to the predictive equation, any three of these were held constant at the midpoint of the experimental range while the other variables were changed. Figures 9 through 13 present the plots for the prediction of flux as a function of the operating parameters.

Both rotor speed and feed pressure were shown in the model to interact with solids concentration. This effect can be seen in Figures 9 and 10 as a change in the slope of surfaces between parallel x and y axes, but is most evident in Figure 10, where the slope of the pressure effect on the flux actually changes sign as solids concentration is changed from 1% to 30% (-1 to +1). The remaining surface plots, Figures 11 through 13, present surfaces without interactions including, respectively, rotor speed versus pressure, temperature versus solids concentration, and time versus solids concentration. Note that the interaction terms drop out of the coded modeling equations when the variables are held constant at the midpoint values (0). These figures show that the response to each of the modeling parameters ranges from nearly linear, under certain conditions such as in Figure 8, to that of significant curvature as shown in the other figures.

Figure 9. Predicted flux response surface – constant temperature, pressure, and time.

Figure 10. Predicted flux response surface – constant temperature, rotor speed, and time.

Figure 11. Predicted flux response surface – constant temperature, solids, and time.

Figure 12. Predicted flux response surface – constant pressure, rotor speed, and time.

Figure 13. Predicted flux response surface – constant temperature, rotor speed, and pressure.

4.3.4 Long-Term Testing

After completion of the previous test matrix, the rotor assembly was fitted with new membranes to test their long-term (200-hr) performance for particle separation. The nominal conditions for the long-term test were as follows: 75 psig feed pressure, 120°F feed temperature, 2000 rpm rotor speed, and 15 wt% solids. The equipment was successfully operated for approximately 100 hr before the run was terminated because of ancillary equipment failure. However, enough data were acquired to test the time dependency factor found to be very significant in the model.

Figure 14 presents the membrane permeate flux data and a variety of modeling data as a function of time. The flux data were acquired at 30-min intervals and were logged as point measurements. The best fit of the flux data was found to be linear, with an $R^2 = 0.848$, while an exponential fit followed with an $R^2 = 0.830$ (these data are not shown in the figure). Even though the best fit was shown to be linear, more data would be required to confirm this conclusion, since one might expect the flux rate to approach zero asymptotically rather than linearly, or possibly the flux rate would level off and never reach zero. In any case, the exponential model derived from the experimental data is a very good approximation to this type of data.

The curves plotted in Figure 14 present various scenarios for application of this model to the data acquired for the new membranes. The line in this figure labeled "Model" and denoted by the dotted line is for the application of the derived model (Equation 1) to the long-term testing. The values for pressure, temperature, rotor speed, and solids concentration were held constant, with operating time being the only variable changed. In this case, the model overpredicts the permeate flux, but generally reflects the trend of the data. However, there is no reason to expect the new

Figure 14. Permeate flux and modeling data as a function of time.

membranes to have identical baseline flux rates to the old set of membranes. For this reason, the intercept to the original model was adjusted from 1.448 to 1.369 in Equation 1 to produce the solid-line curve, since the intercept dictates the baseline value for a given set of test parameters. The third curve in Figure 14, represented by the dashed line, shows the "best fit" that could be made if the slope of the time variable in the model (Equation 1) was shifted from -0.002572 to -0.002100 , and again, the intercept changed to a value of 1.355 to reflect the adjustment in baseline values.

The adjustment of the model's intercept to better reflect these data can be justified, especially since at this time no data exist on membrane variability. If this variability were determined, then the discrepancy between the model fit and the actual data could be better categorized as a chance versus a true difference in the membranes. Changing the slope of the time variable in Equation 1 is not justifiable, except to model the latter data set, since the original experimental test matrix was performed at a variety of run conditions that may also influence the time-dependent wearing of the membrane.

4.4 Preliminary Evaluation of Turbulence Promoters

Following each test run used to develop data for statistical analysis, the membranes were removed from the stationary housing, rinsed with tap water to remove any solids from the membrane surface, and inspected for wear and any damage. At the conclusion of both matrix testing and the extended run, membrane wear was noticeable. The original blue color of the titanium dioxide coating was worn from the perimeter of the membrane, approximately 1.5 inches from the outer edge. In order to investigate the wear or abrasion of the membrane coating, the composition of the membrane surface was analyzed by scanning electron microscopy (SEM). SEM analysis confirmed that the TiO_2 coating had been abraded from the membrane surface, exposing the stainless steel support plate. Table 8 lists the normalized weight percent composition of selected

oxides across the membrane surface, from the outside edge to the inner diameter of the membrane. The data in columns "Outside" and "Inside" were areas covered by the stainless steel retaining ring and were not directly exposed to the surrogate test solution or the fluid dynamics encountered by the other portions of the membrane. Titanium dioxide was the major surface component in the covered regions (outside and inside) and the inner portion of the membrane. However, in the areas where surface abrasion was visibly evident (outer and middle), the predominant metal oxide was iron. Chromium oxide was also present at higher levels in the regions of visible wear. These data indicate that the surface coating ($\text{TiO}_2/\text{Al}_2\text{O}_3$) had indeed been abraded from the surface, exposing the stainless steel support disk.

Several factors may contribute to the observed wear pattern. The first relates to a function of membrane velocity. The highest velocity occurs at the outside perimeter of the membrane, where the abrasion was most apparent. The second factor was the accumulation of a thin layer of clay solids that collected on the membrane surface near the inner portions of the membrane. This buildup of solids in this region prevents the scouring action observed near the outer perimeter.

The net effect on filtration performance due to membrane wear or solids buildup on the inner portions of the membrane surface is not known. However, based on the statistical analysis of operational data and data developed during the extended run, performance, as measured by permeate flux, decreased with time. It should be noted that permeate quality, as measured by

TABLE 8

	Membrane Composition at the Completion of Testing				
	Normalized Weight Percent				
	Outside	Outer	Middle	Inner	Inside
Oxide					
NaO_2	1.2	0.0	0.0	0.9	1.2
Al_2O_3	2.9	1.1	0.6	2.6	2.9
SiO_2	4.1	3.0	2.5	9.8	4.1
P_2O_5	0.2	0.0	0.4	0.2	0.2
SO_3	0.2	1.1	1.2	0.0	0.2
ClO	0.2	0.0	0.0	0.0	0.2
K_2O	0.2	0.0	0.0	0.0	0.2
CaO	0.0	0.0	0.1	0.3	0.0
TiO_2	75.1	23.4	25.1	75.3	75.1
Cr_2O_3	5.5	19.4	17.6	3.6	5.5
Fe_2O_3	10.5	52.0	52.3	7.3	10.5

turbidity and suspended solids, showed no deterioration throughout all testing, producing a turbidity-free permeate. Additionally, the observed wear is a membrane-related phenomena, and is not a system deficiency.

The ST-IIL system employs the use of "wagon wheel" turbulence promoters on either side of the membrane disk to create a shear force across the membrane surface to prevent the development of solids buildup. Based on membrane abrasion and solids buildup observed during testing, it appears that the current configuration of the turbulence promoters allows membrane cleaning where linear velocities are greater than approximately 17.5 fps. Optimization of the design of the turbulence promoter should allow the entire surface to be free of solids buildup, which should improve permeate flux. The effect of turbulence promoter optimization on membrane wear is not readily apparent at this time. However, under optimized turbulence conditions, it may be anticipated that higher rotational speeds would not be required to maintain self-cleaning membranes.

5.0 CONCLUSIONS

SpinTek centrifugal membrane filtration has applications in several program elements of the EM focus areas and as a crosscutting technology. Its unique ability in combining centrifugal force with membrane filtration allows for the continuous removal and concentration of selected contaminants from groundwater, surface water, process water, process chemicals, etc. The combination of the ceramic membrane with the low-fouling characteristics for the rotary system results in SpinTek's ability to concentrate hazardous wastewater to a slurry-type level and fractionate dilute low-level wastes, high-level wastes, and hazardous waste and reduce tank sludge. The system does not generate any secondary waste streams, and because it is self-contained, it reduces worker exposure and chance of spillage.

Rotating membrane filtration technology, such as the process developed by SpinTek Membrane Systems, Inc., appears to have great potential in remediation efforts currently under way at the various contaminated DOE sites. The greatest benefits of centrifugal membrane ultrafiltration include its efficient separations, efficient processing, and high-rate volume reduction capabilities. The innovative membrane filtration system coupled with centrifugal force gives this crosscutting technology distinct advantages over conventional ultrafiltration processes. It can accept feed streams containing relatively large particulate sizes, unlike hollow-fiber ultrafilters, and can maintain high permeate flux at significantly higher feed solids concentrations than tubular or spirally wound ultrafiltration units. Rotating membrane ultrafiltration could be one step in a series of remediation operations or employed in series using multiple membrane types to selectively remove various waste components. Used as a stand-alone unit, it is capable of producing a permeate free of colloidal and suspended solids and a low-volume concentrate stream. The SpinTek technology may also be used as a complement to other cleanup efforts.

Phase I research efforts have indicated that the SpinTek process is well suited for application to the cleanup of liquid mixed-waste streams at DOE facilities. The process configuration provides higher flux rates per unit membrane area in easily transportable, compact treatment units. The process is a near-tank technology that can be easily integrated with other unit operations to improve the operation and efficiency of downstream unit operations, such as adsorption and ion exchange.

Filtration performance of the SpinTek process may be further enhanced through efforts to optimize the design of the turbulence promoters to allow the entire surface to be free of solids buildup, which should improve permeate flux. Optimization of the turbulence promoter design should be considered, followed by scaleup of the process to effectively interface with other treatment technologies in use at DOE facilities.

*Energy &
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APPENDIX A
INTERIM PROJECT REPORT

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SPINTEK INTERIM PROJECT REPORT

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APPENDIX B

MEMBRANE SCREENING TEST DATA

SpinTek Static Test Cell STC-X4

--- 0.25 um TiO2/Al2O3 - - - 0.25 um TiO2/SiO2 - - - 0.3 um TiO2/TiO2

ELAPSED TIME (DD:HH:MM)

SCRN1							
0.25 um TiO₂/Al₂O₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
14:54	0:00	29.0	7.0	0.8	89	7.5	58
14:55	0:00	28.0	7.0	0.8	89	8.8	68
14:55	0:01	32.0	7.0	0.9	90	8.8	68
14:56	0:01	31.0	7.0	0.9	89	8.8	68
14:56	0:02	31.0	7.0	0.9	90	8.8	68
14:57	0:02	31.0	7.0	0.9	90	8.8	68
14:57	0:03	31.0	7.0	0.9	89	8.8	68
14:58	0:03	31.0	7.0	0.9	90	9.2	71
14:58	0:04	31.0	7.0	0.9	89	9.2	71
14:59	0:04	30.0	7.0	0.9	90	9.2	71
14:59	0:05	27.0	6.0	0.8	90	9.2	71
15:00	0:05	27.0	6.0	0.8	89	9.2	71
15:00	0:06	27.0	6.0	0.8	90	9.2	71
15:01	0:06	30.0	7.0	0.8	89	9.2	71
15:01	0:07	30.0	7.0	0.9	90	8.8	68
15:02	0:07	30.0	7.0	0.8	90	8.8	68
15:02	0:08	28.0	7.0	0.8	89	8.8	68
15:03	0:08	28.0	7.0	0.8	90	8.8	68
15:03	0:09	27.0	7.0	0.8	89	8.8	68
15:04	0:09	27.0	6.0	0.8	89	8.8	68
15:04	0:10	27.0	7.0	0.8	90	8.8	68
15:05	0:10	27.0	7.0	0.8	89	8.3	64
15:05	0:11	27.0	6.0	0.8	90	8.3	64
15:06	0:11	27.0	6.0	0.8	90	8.3	64
15:06	0:12	27.0	6.0	0.8	90	8.3	64
15:07	0:12	27.0	6.0	0.8	90	8.3	64
15:07	0:13	27.0	6.0	0.8	89	8.3	64
15:08	0:13	27.0	6.0	0.8	90	8.3	64
15:09	0:14	27.0	6.0	0.8	89	8.3	64
15:09	0:14	27.0	7.0	0.8	89	8.0	62
15:10	0:15	30.0	7.0	0.8	90	8.0	62
15:10	0:15	29.0	7.0	0.8	89	8.0	62
15:11	0:16	29.0	7.0	0.8	90	8.0	62
15:11	0:16	29.0	7.0	0.8	89	8.0	62
15:12	0:17	29.0	7.0	0.8	89	8.0	62
15:12	0:18	29.0	7.0	0.8	90	8.0	62
15:13	0:18	29.0	7.0	0.8	89	8.4	65
15:13	0:19	29.0	7.0	0.8	90	8.4	65
15:14	0:19	29.0	7.0	0.8	89	8.4	65
15:14	0:20	29.0	7.0	0.8	89	8.4	65
15:15	0:20	29.0	7.0	0.8	90	9.3	72
15:15	0:21	29.0	7.0	0.8	89	9.3	72
15:16	0:21	29.0	7.0	0.8	90	9.3	72
15:16	0:22	29.0	7.0	0.8	89	9.3	72

0.25 um TiO ₂ /Al ₂ O ₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
15:17	0:22	29.0	7.0	0.8	90	9.3	72
15:17	0:23	29.0	7.0	0.8	90	8.7	67
15:18	0:23	29.0	7.0	0.8	89	8.7	67
15:18	0:24	29.0	7.0	0.8	90	8.7	67
15:19	0:24	28.0	7.0	0.8	89	8.7	67
15:19	0:25	29.0	7.0	0.8	90	8.7	67
15:20	0:25	28.0	7.0	0.8	89	8.7	67
15:21	0:26	28.0	7.0	0.8	90	8.7	67
15:21	0:26	30.0	7.0	0.8	90	8.7	67
15:22	0:27	30.0	7.0	0.8	89	9.6	74
15:22	0:27	30.0	7.0	0.8	90	9.6	74
15:23	0:28	29.0	7.0	0.8	89	7.6	59
15:23	0:29	29.0	7.0	0.8	89	7.6	59
15:24	0:29	29.0	7.0	0.8	90	7.6	59
15:24	0:30	29.0	7.0	0.8	89	7.6	59
15:25	0:30	29.0	7.0	0.8	90	7.6	59
15:25	0:31	29.0	7.0	0.8	89	7.6	59
15:26	0:31	29.0	7.0	0.8	90	7.6	59
15:26	0:32	29.0	7.0	0.8	90	7.6	59
15:27	0:32	29.0	7.0	0.8	89	8.5	66
15:27	0:33	29.0	7.0	0.8	90	8.5	66
15:28	0:33	29.0	7.0	0.8	89	8.5	66
15:28	0:34	29.0	7.0	0.8	90	8.5	66
15:29	0:34	29.0	7.0	0.8	90	8.5	66
15:29	0:35	29.0	7.0	0.8	89	8.4	65
15:30	0:35	29.0	7.0	0.8	90	8.4	65
15:30	0:36	29.0	7.0	0.8	90	8.4	65
15:31	0:36	29.0	7.0	0.8	90	8.4	65
15:31	0:37	29.0	7.0	0.8	90	8.4	65
15:32	0:37	29.0	7.0	0.8	89	8.4	65
15:32	0:38	29.0	7.0	0.8	90	8.4	65
15:33	0:38	29.0	7.0	0.8	89	8.4	65
15:33	0:39	29.0	7.0	0.8	89	8.4	65
15:34	0:39	29.0	7.0	0.8	90	8.4	65
15:34	0:40	29.0	7.0	0.8	89	8.4	65
15:35	0:40	29.0	7.0	0.8	90	8.4	65
15:35	0:41	29.0	7.0	0.8	89	8.4	65
15:36	0:41	28.0	7.0	0.8	89	7.6	59
15:36	0:42	29.0	7.0	0.8	90	7.6	59
15:37	0:42	29.0	7.0	0.8	89	7.6	59
15:37	0:43	28.0	6.0	0.8	90	7.6	59
15:38	0:43	28.0	6.0	0.8	89	7.6	59
15:39	0:44	28.0	6.0	0.8	90	8.0	62
15:39	0:44	28.0	6.0	0.8	90	8.0	62
15:40	0:45	28.0	6.0	0.8	89	8.0	62

0.25 μm $\text{TiO}_2/\text{Al}_2\text{O}_3$							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
15:40	0:46	28.0	6.0	0.8	90	7.7	59
15:41	0:46	28.0	6.0	0.8	89	7.7	59
15:41	0:47	28.0	7.0	0.8	90	7.7	59
15:42	0:47	28.0	6.0	0.8	90	7.7	59
15:42	0:48	28.0	6.0	0.8	89	7.7	59
15:43	0:48	27.0	6.0	0.8	90	7.7	59
15:43	0:49	27.0	6.0	0.8	90	7.7	59
15:44	0:49	27.0	6.0	0.8	89	7.7	59
15:44	0:50	27.0	6.0	0.8	90	8.0	62
15:45	0:50	27.0	6.0	0.8	89	8.0	62
15:45	0:51	27.0	6.0	0.8	90	8.0	62
15:46	0:51	27.0	6.0	0.8	90	8.0	62
15:46	0:52	27.0	6.0	0.8	89	8.0	62
15:47	0:52	27.0	6.0	0.8	90	8.0	62
15:47	0:53	27.0	6.0	0.8	89	8.0	62
15:48	0:53	27.0	6.0	0.8	90	8.0	62
15:48	0:54	27.0	6.0	0.8	90	8.0	62
15:49	0:54	27.0	6.0	0.8	89	8.0	62
15:49	0:55	27.0	6.0	0.8	90	8.0	62
15:50	0:55	27.0	6.0	0.8	89	8.0	62
15:50	0:56	27.0	6.0	0.8	90	8.0	62
15:51	0:56	27.0	6.0	0.8	90	8.0	62
15:51	0:57	27.0	6.0	0.8	89	7.0	54
15:52	0:57	27.0	6.0	0.8	90	7.0	54
15:52	0:58	27.0	6.0	0.8	90	7.0	54
15:53	0:58	27.0	6.0	0.8	89	7.0	54
15:54	0:59	27.0	6.0	0.8	90	7.0	54
15:54	0:59	27.0	6.0	0.8	89	7.0	54
15:55	1:00	27.0	6.0	0.8	90	7.7	59
Average		28.4	6.6	0.8	89.6	8.3	63.8
Average Test Conditions: SCRN1.XLS				Feed Pressure = 28.4 psig			
				Concentrate Pressure = 6.6 psig			
Date Run: 20-Apr-96				Feed Flow = 0.8 gpm			
				Temp. = 90 F			

SCRN1							
0.25 um TiO₂/SiO₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
14:54	0:00	29.0	7.0	0.8	89	7.7	59
14:55	0:00	28.0	7.0	0.8	89	7.7	59
14:55	0:01	32.0	7.0	0.9	90	9.7	75
14:56	0:01	31.0	7.0	0.9	89	9.7	75
14:56	0:02	31.0	7.0	0.9	90	9.7	75
14:57	0:02	31.0	7.0	0.9	90	9.7	75
14:57	0:03	31.0	7.0	0.9	89	9.7	75
14:58	0:03	31.0	7.0	0.9	90	9.7	75
14:58	0:04	31.0	7.0	0.9	89	9.7	75
14:59	0:04	30.0	7.0	0.9	90	9.9	76
14:59	0:05	27.0	6.0	0.8	90	9.9	76
15:00	0:05	27.0	6.0	0.8	89	9.9	76
15:00	0:06	27.0	6.0	0.8	90	9.9	76
15:01	0:06	30.0	7.0	0.8	89	9.9	76
15:01	0:07	30.0	7.0	0.9	90	9.9	76
15:02	0:07	30.0	7.0	0.8	90	9.9	76
15:02	0:08	28.0	7.0	0.8	89	9.7	75
15:03	0:08	28.0	7.0	0.8	90	9.7	75
15:03	0:09	27.0	7.0	0.8	89	9.7	75
15:04	0:09	27.0	6.0	0.8	89	9.7	75
15:04	0:10	27.0	7.0	0.8	90	9.7	75
15:05	0:10	27.0	7.0	0.8	89	9.7	75
15:05	0:11	27.0	6.0	0.8	90	9.7	75
15:06	0:11	27.0	6.0	0.8	90	9.7	75
15:06	0:12	27.0	6.0	0.8	90	8.9	69
15:07	0:12	27.0	6.0	0.8	90	8.9	69
15:08	0:13	27.0	6.0	0.8	89	8.9	69
15:08	0:13	27.0	6.0	0.8	90	8.9	69
15:09	0:14	27.0	6.0	0.8	89	8.9	69
15:09	0:14	27.0	7.0	0.8	89	8.9	69
15:10	0:15	30.0	7.0	0.8	90	8.9	69
15:10	0:15	29.0	7.0	0.8	89	9.7	75
15:11	0:16	29.0	7.0	0.8	90	9.7	75
15:11	0:16	29.0	7.0	0.8	89	8.0	62
15:12	0:17	29.0	7.0	0.8	89	8.0	62
15:12	0:18	29.0	7.0	0.8	90	8.0	62
15:13	0:18	29.0	7.0	0.8	89	8.0	62
15:13	0:19	29.0	7.0	0.8	90	8.0	62
15:14	0:19	29.0	7.0	0.8	89	8.0	62
15:14	0:20	29.0	7.0	0.8	89	8.0	62
15:15	0:20	29.0	7.0	0.8	90	8.0	62
15:15	0:21	29.0	7.0	0.8	89	8.0	62
15:16	0:21	29.0	7.0	0.8	90	8.0	62
15:16	0:22	29.0	7.0	0.8	89	8.0	62

0.25 um TiO ₂ /SiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
15:17	0:22	29.0	7.0	0.8	90	8.0	62
15:17	0:23	29.0	7.0	0.8	90	8.0	62
15:18	0:23	29.0	7.0	0.8	89	8.0	62
15:18	0:24	29.0	7.0	0.8	90	8.0	62
15:19	0:24	28.0	7.0	0.8	89	8.8	68
15:20	0:25	29.0	7.0	0.8	90	8.8	68
15:20	0:25	28.0	7.0	0.8	89	8.8	68
15:21	0:26	28.0	7.0	0.8	90	8.8	68
15:21	0:26	30.0	7.0	0.8	90	8.8	68
15:22	0:27	30.0	7.0	0.8	89	8.8	68
15:22	0:27	30.0	7.0	0.8	90	8.8	68
15:23	0:28	29.0	7.0	0.8	89	8.8	68
15:23	0:29	29.0	7.0	0.8	89	8.8	68
15:24	0:29	29.0	7.0	0.8	90	9.7	75
15:24	0:30	29.0	7.0	0.8	89	9.7	75
15:25	0:30	29.0	7.0	0.8	90	9.7	75
15:25	0:31	29.0	7.0	0.8	89	9.7	75
15:26	0:31	29.0	7.0	0.8	90	9.7	75
15:26	0:32	29.0	7.0	0.8	90	9.7	75
15:27	0:32	29.0	7.0	0.8	89	9.7	75
15:27	0:33	29.0	7.0	0.8	90	9.7	75
15:28	0:33	29.0	7.0	0.8	89	9.7	75
15:28	0:34	29.0	7.0	0.8	90	9.7	75
15:29	0:34	29.0	7.0	0.8	90	9.7	75
15:29	0:35	29.0	7.0	0.8	89	9.7	75
15:30	0:35	29.0	7.0	0.8	90	9.7	75
15:30	0:36	29.0	7.0	0.8	90	10.5	81
15:31	0:36	29.0	7.0	0.8	90	10.5	81
15:31	0:37	29.0	7.0	0.8	90	10.5	81
15:32	0:37	29.0	7.0	0.8	89	10.5	81
15:32	0:38	29.0	7.0	0.8	90	10.5	81
15:33	0:38	29.0	7.0	0.8	89	10.5	81
15:33	0:39	29.0	7.0	0.8	89	10.5	81
15:34	0:39	29.0	7.0	0.8	90	10.5	81
15:34	0:40	29.0	7.0	0.8	89	9.2	71
15:35	0:40	29.0	7.0	0.8	90	9.2	71
15:35	0:41	29.0	7.0	0.8	89	9.2	71
15:36	0:41	28.0	7.0	0.8	89	9.2	71
15:37	0:42	29.0	7.0	0.8	90	9.2	71
15:37	0:42	29.0	7.0	0.8	89	9.2	71
15:38	0:43	28.0	6.0	0.8	90	9.2	71
15:38	0:43	28.0	6.0	0.8	89	9.2	71
15:39	0:44	28.0	6.0	0.8	90	9.2	71
15:39	0:44	28.0	6.0	0.8	90	9.2	71
15:40	0:45	28.0	6.0	0.8	89	9.2	71

0.25 um TiO ₂ /SiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
15:40	0:46	28.0	6.0	0.8	90	9.2	71
15:41	0:46	28.0	6.0	0.8	89	9.2	71
15:41	0:47	28.0	7.0	0.8	90	8.6	66
15:42	0:47	28.0	6.0	0.8	90	8.6	66
15:42	0:48	28.0	6.0	0.8	89	8.6	66
15:43	0:48	27.0	6.0	0.8	90	8.6	66
15:43	0:49	27.0	6.0	0.8	90	8.6	66
15:44	0:49	27.0	6.0	0.8	89	8.6	66
15:44	0:50	27.0	6.0	0.8	90	8.6	66
15:45	0:50	27.0	6.0	0.8	89	8.6	66
15:45	0:51	27.0	6.0	0.8	90	8.6	66
15:46	0:51	27.0	6.0	0.8	90	8.6	66
15:46	0:52	27.0	6.0	0.8	89	8.6	66
15:47	0:52	27.0	6.0	0.8	90	7.5	58
15:47	0:53	27.0	6.0	0.8	89	7.5	58
15:48	0:53	27.0	6.0	0.8	90	7.5	58
15:48	0:54	27.0	6.0	0.8	90	7.5	58
15:49	0:54	27.0	6.0	0.8	89	7.5	58
15:49	0:55	27.0	6.0	0.8	90	7.5	58
15:50	0:55	27.0	6.0	0.8	89	7.5	58
15:50	0:56	27.0	6.0	0.8	90	7.5	58
15:51	0:56	27.0	6.0	0.8	90	7.5	58
15:51	0:57	27.0	6.0	0.8	89	7.5	58
15:52	0:57	27.0	6.0	0.8	90	7.5	58
15:52	0:58	27.0	6.0	0.8	90	7.5	58
15:53	0:58	27.0	6.0	0.8	89	7.5	58
15:54	0:59	27.0	6.0	0.8	90	7.5	58
15:54	0:59	27.0	6.0	0.8	89	7.5	58
15:55	1:00	27.0	6.0	0.8	90	7.5	58
Average		28.4	6.6	0.8	89.6	8.9	69.0
Average Test Conditions: SCRN1.XLS				Feed Pressure = 28.4 psig			
				Concentrate Pressure = 6.6 psig			
Date Run: 20-Apr-96				Feed Flow = 0.8 gpm			
				Temp. = 90 F			

SCRN1							
0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
14:54	0:00	29.0	7.0	0.8	89	9.8	76
14:55	0:00	28.0	7.0	0.8	89	9.8	76
14:55	0:01	32.0	7.0	0.9	90	9.8	76
14:56	0:01	31.0	7.0	0.9	89	9.8	76
14:56	0:02	31.0	7.0	0.9	90	9.8	76
14:57	0:02	31.0	7.0	0.9	90	9.6	74
14:57	0:03	31.0	7.0	0.9	89	9.6	74
14:58	0:03	31.0	7.0	0.9	90	9.6	74
14:58	0:04	31.0	7.0	0.9	89	9.6	74
14:59	0:04	30.0	7.0	0.9	90	9.6	74
14:59	0:05	27.0	6.0	0.8	90	9.6	74
15:00	0:05	27.0	6.0	0.8	89	8.4	65
15:00	0:06	27.0	6.0	0.8	90	8.4	65
15:01	0:06	30.0	7.0	0.8	89	8.4	65
15:01	0:07	30.0	7.0	0.9	90	8.4	65
15:02	0:07	30.0	7.0	0.8	90	8.4	65
15:02	0:08	28.0	7.0	0.8	89	8.4	65
15:03	0:08	28.0	7.0	0.8	90	8.4	65
15:03	0:09	27.0	7.0	0.8	89	8.4	65
15:04	0:09	27.0	6.0	0.8	89	8.6	66
15:04	0:10	27.0	7.0	0.8	90	8.6	66
15:05	0:10	27.0	7.0	0.8	89	8.6	66
15:05	0:11	27.0	6.0	0.8	90	8.6	66
15:06	0:11	27.0	6.0	0.8	90	8.6	66
15:06	0:12	27.0	6.0	0.8	90	8.6	66
15:07	0:12	27.0	6.0	0.8	90	8.6	66
15:08	0:13	27.0	6.0	0.8	89	8.5	66
15:08	0:13	27.0	6.0	0.8	90	8.5	66
15:09	0:14	27.0	6.0	0.8	89	8.5	66
15:09	0:14	27.0	7.0	0.8	89	8.5	66
15:10	0:15	30.0	7.0	0.8	90	8.5	66
15:10	0:15	29.0	7.0	0.8	89	8.5	66
15:11	0:16	29.0	7.0	0.8	90	8.5	66
15:11	0:16	29.0	7.0	0.8	89	8.5	66
15:12	0:17	29.0	7.0	0.8	89	8.5	66
15:12	0:18	29.0	7.0	0.8	90	8.5	66
15:13	0:18	29.0	7.0	0.8	89	8.5	66
15:13	0:19	29.0	7.0	0.8	90	8.5	66
15:14	0:19	29.0	7.0	0.8	89	8.8	68
15:14	0:20	29.0	7.0	0.8	89	8.8	68
15:15	0:20	29.0	7.0	0.8	90	8.8	68
15:15	0:21	29.0	7.0	0.8	89	8.8	68
15:16	0:21	29.0	7.0	0.8	90	8.8	68
15:16	0:22	29.0	7.0	0.8	89	7.6	59

0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
15:17	0:22	29.0	7.0	0.8	90	7.6	59
15:17	0:23	29.0	7.0	0.8	90	7.6	59
15:18	0:23	29.0	7.0	0.8	89	7.6	59
15:18	0:24	29.0	7.0	0.8	90	7.6	59
15:19	0:24	28.0	7.0	0.8	89	7.6	59
15:20	0:25	29.0	7.0	0.8	90	7.6	59
15:20	0:25	28.0	7.0	0.8	89	9.7	75
15:21	0:26	28.0	7.0	0.8	90	9.7	75
15:21	0:26	30.0	7.0	0.8	90	9.7	75
15:22	0:27	30.0	7.0	0.8	89	9.7	75
15:22	0:27	30.0	7.0	0.8	90	9.7	75
15:23	0:28	29.0	7.0	0.8	89	9.7	75
15:23	0:29	29.0	7.0	0.8	89	9.7	75
15:24	0:29	29.0	7.0	0.8	90	9.7	75
15:24	0:30	29.0	7.0	0.8	89	9.7	75
15:25	0:30	29.0	7.0	0.8	90	9.7	75
15:25	0:31	29.0	7.0	0.8	89	8.3	64
15:26	0:31	29.0	7.0	0.8	90	8.3	64
15:26	0:32	29.0	7.0	0.8	90	8.3	64
15:27	0:32	29.0	7.0	0.8	89	8.3	64
15:27	0:33	29.0	7.0	0.8	90	8.3	64
15:28	0:33	29.0	7.0	0.8	89	8.4	65
15:28	0:34	29.0	7.0	0.8	90	8.4	65
15:29	0:34	29.0	7.0	0.8	90	8.4	65
15:29	0:35	29.0	7.0	0.8	89	8.4	65
15:30	0:35	29.0	7.0	0.8	90	8.4	65
15:30	0:36	29.0	7.0	0.8	90	8.4	65
15:31	0:36	29.0	7.0	0.8	90	8.4	65
15:31	0:37	29.0	7.0	0.8	90	8.4	65
15:32	0:37	29.0	7.0	0.8	89	7.3	56
15:32	0:38	29.0	7.0	0.8	90	7.3	56
15:33	0:38	29.0	7.0	0.8	89	7.3	56
15:33	0:39	29.0	7.0	0.8	89	7.3	56
15:34	0:39	29.0	7.0	0.8	90	7.3	56
15:34	0:40	29.0	7.0	0.8	89	7.3	56
15:35	0:40	29.0	7.0	0.8	90	7.3	56
15:36	0:41	29.0	7.0	0.8	89	7.3	56
15:36	0:41	28.0	7.0	0.8	89	7.3	56
15:37	0:42	29.0	7.0	0.8	90	7.3	56
15:37	0:42	29.0	7.0	0.8	89	7.1	55
15:38	0:43	28.0	6.0	0.8	90	7.1	55
15:38	0:43	28.0	6.0	0.8	89	7.1	55
15:39	0:44	28.0	6.0	0.8	90	7.1	55
15:39	0:44	28.0	6.0	0.8	90	7.1	55
15:40	0:45	28.0	6.0	0.8	89	7.1	55

0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
15:40	0:46	28.0	6.0	0.8	90	7.1	55
15:41	0:46	28.0	6.0	0.8	89	7.1	55
15:41	0:47	28.0	7.0	0.8	90	7.1	55
15:42	0:47	28.0	6.0	0.8	90	7.1	55
15:42	0:48	28.0	6.0	0.8	89	7.1	55
15:43	0:48	27.0	6.0	0.8	90	8.0	62
15:43	0:49	27.0	6.0	0.8	90	8.0	62
15:44	0:49	27.0	6.0	0.8	89	8.0	62
15:44	0:50	27.0	6.0	0.8	90	8.0	62
15:45	0:50	27.0	6.0	0.8	89	8.0	62
15:45	0:51	27.0	6.0	0.8	90	8.0	62
15:46	0:51	27.0	6.0	0.8	90	6.6	51
15:46	0:52	27.0	6.0	0.8	89	6.6	51
15:47	0:52	27.0	6.0	0.8	90	6.6	51
15:47	0:53	27.0	6.0	0.8	89	6.6	51
15:48	0:53	27.0	6.0	0.8	90	6.6	51
15:48	0:54	27.0	6.0	0.8	90	7.2	56
15:49	0:54	27.0	6.0	0.8	89	7.2	56
15:49	0:55	27.0	6.0	0.8	90	7.2	56
15:50	0:55	27.0	6.0	0.8	89	7.3	56
15:50	0:56	27.0	6.0	0.8	90	7.3	56
15:51	0:56	27.0	6.0	0.8	90	7.3	56
15:51	0:57	27.0	6.0	0.8	89	7.3	56
15:52	0:57	27.0	6.0	0.8	90	7.3	56
15:52	0:58	27.0	6.0	0.8	90	7.3	56
15:53	0:58	27.0	6.0	0.8	89	7.1	55
15:54	0:59	27.0	6.0	0.8	90	7.1	55
15:54	0:59	27.0	6.0	0.8	89	7.1	55
15:55	1:00	27.0	6.0	0.8	90	7.1	55
Average		28.4	6.6	0.8	89.6	8.2	63.1
Average Test Conditions: SCRN1.XLS				Feed Pressure = 28.4 psig			
				Concentrate Pressure = 6.6 psig			
Date Run: 20-Apr-96				Feed Flow = 0.8 gpm			
				Temp. = 90 F			

SpinTek Static Test Cell STC-X4

SCRN2							
0.25 um TiO ₂ /Al ₂ O ₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
19:16	0:00	75.0	42.0	1.0	90	20.4	157
19:18	0:01	75.0	42.0	1.0	89	20.0	154
19:23	0:07	75.0	42.0	1.0	89	20.0	154
19:24	0:08	75.0	42.0	1.0	89	20.0	154
19:27	0:11	75.0	42.0	1.0	89	20.0	154
19:29	0:13	75.0	42.0	1.0	89	5.9	46
19:31	0:15	75.0	42.0	1.0	89	19.1	147
19:33	0:17	75.0	42.0	1.0	90	19.4	150
19:35	0:19	75.0	41.0	1.0	90	18.8	145
19:37	0:21	75.0	42.0	1.0	90	18.7	144
19:39	0:23	75.0	42.0	1.0	90	17.6	136
19:41	0:25	75.0	41.0	1.0	90	17.6	136
19:43	0:27	75.0	41.0	1.0	89	18.0	139
19:45	0:29	75.0	42.0	1.0	89	19.2	148
19:47	0:31	75.0	41.0	1.0	90	17.4	134
19:49	0:33	75.0	41.0	1.0	89	18.4	142
19:51	0:35	75.0	41.0	1.0	90	21.4	165
19:53	0:37	75.0	41.0	1.0	90	18.5	143
19:55	0:39	75.0	41.0	1.0	90	17.0	131
19:57	0:41	75.0	41.0	1.0	90	18.5	143
19:59	0:43	75.0	41.0	1.0	90	18.5	143
20:01	0:45	75.0	41.0	1.0	89	18.9	146
20:03	0:47	75.0	41.0	1.0	90	19.2	148
20:05	0:49	75.0	41.0	1.0	90	17.5	135
20:07	0:51	75.0	41.0	1.0	89	20.6	159
20:09	0:53	75.0	42.0	1.0	90	20.8	161
20:11	0:55	75.0	42.0	1.0	90	18.8	145
20:13	0:57	0.0	0.0	0.0	89	18.8	145
20:15	0:59	74.0	41.0	0.7	89	18.8	145
20:17	1:01	75.0	41.0	1.0	89	16.2	125
20:19	1:03	75.0	42.0	1.0	90	18.0	139
20:21	1:05	75.0	42.0	1.0	90	18.6	144
20:23	1:07	75.0	41.0	1.0	90	18.6	144
20:25	1:09	75.0	41.0	1.0	90	17.8	137
20:27	1:11	75.0	41.0	1.0	90	18.9	146
20:30	1:13	75.0	41.0	1.0	90	17.5	135
Average		75.0	41.4	1.0	89.6	18.4	142.1
Average Test Conditions: SCRN2.XLS				Feed Pressure = 72.5 psig			
				Concentrate Pressure = 39.9 psig			
Date Run: 20-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN2							
0.25 um TiO ₂ /SiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
19:16	0:00	75.0	42.0	1.0	90	22.0	170
19:18	0:01	75.0	42.0	1.0	89	20.8	161
19:23	0:07	75.0	42.0	1.0	89	19.8	153
19:24	0:08	75.0	42.0	1.0	89	19.8	153
19:27	0:11	75.0	42.0	1.0	89	19.8	153
19:29	0:13	75.0	42.0	1.0	89	19.1	147
19:31	0:15	75.0	42.0	1.0	89	19.8	153
19:33	0:17	75.0	42.0	1.0	90	19.7	152
19:35	0:19	75.0	41.0	1.0	90	19.7	152
19:37	0:21	75.0	42.0	1.0	90	18.8	145
19:39	0:23	75.0	42.0	1.0	90	19.6	151
19:41	0:25	75.0	41.0	1.0	90	19.2	148
19:43	0:27	75.0	41.0	1.0	89	19.4	150
19:45	0:29	75.0	42.0	1.0	89	18.7	144
19:47	0:31	75.0	41.0	1.0	90	18.4	142
19:49	0:33	75.0	41.0	1.0	89	19.4	150
19:51	0:35	75.0	41.0	1.0	90	18.1	140
19:53	0:37	75.0	41.0	1.0	90	18.1	140
19:55	0:39	75.0	41.0	1.0	90	17.7	137
19:57	0:41	75.0	41.0	1.0	90	17.7	137
19:59	0:43	75.0	41.0	1.0	90	18.8	145
20:01	0:45	75.0	41.0	1.0	89	19.7	152
20:03	0:47	75.0	41.0	1.0	90	17.5	135
20:05	0:49	75.0	41.0	1.0	90	18.0	139
20:07	0:51	75.0	41.0	1.0	89	18.5	143
20:09	0:53	75.0	42.0	1.0	90	18.5	143
20:11	0:55	75.0	42.0	1.0	90	18.2	140
20:13	0:57	0.0	0.0	0.0	89	19.7	152
20:15	0:59	74.0	41.0	0.7	89	19.7	152
20:17	1:01	75.0	41.0	1.0	89	19.7	152
20:19	1:03	75.0	42.0	1.0	90	17.5	135
20:21	1:05	75.0	42.0	1.0	90	18.9	146
20:24	1:07	75.0	41.0	1.0	90	18.5	143
20:26	1:09	75.0	41.0	1.0	90	19.6	151
20:28	1:11	75.0	41.0	1.0	90	20.2	156
20:30	1:13	75.0	41.0	1.0	90	18.9	146
Average		75.0	41.4	1.0	89.6	19.1	147.2
Average Test Conditions: SCRN2.XLS				Feed Pressure = 72.5 psig			
				Concentrate Pressure = 39.9 psig			
Date Run: 20-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN2							
0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
19:16	0:00	75.0	42.0	1.0	90	21.4	165
19:18	0:01	75.0	42.0	1.0	89	20.2	156
19:23	0:07	75.0	42.0	1.0	89	20.4	157
19:24	0:08	75.0	42.0	1.0	89	20.4	157
19:27	0:11	75.0	42.0	1.0	89	20.4	157
19:29	0:13	75.0	42.0	1.0	89	25.0	193
19:31	0:15	75.0	42.0	1.0	89	20.5	158
19:33	0:17	75.0	42.0	1.0	90	24.0	185
19:35	0:19	75.0	41.0	1.0	90	21.1	163
19:37	0:21	75.0	42.0	1.0	90	18.6	144
19:39	0:23	75.0	42.0	1.0	90	19.6	151
19:41	0:25	75.0	41.0	1.0	90	19.1	147
19:43	0:27	75.0	41.0	1.0	89	18.0	139
19:45	0:29	75.0	42.0	1.0	89	18.0	139
19:47	0:31	75.0	41.0	1.0	90	18.0	139
19:49	0:33	75.0	41.0	1.0	89	18.6	144
19:51	0:35	75.0	41.0	1.0	90	22.5	174
19:53	0:37	75.0	41.0	1.0	90	18.4	142
19:55	0:39	75.0	41.0	1.0	90	18.7	144
19:57	0:41	75.0	41.0	1.0	90	18.5	143
19:59	0:43	75.0	41.0	1.0	90	17.3	134
20:01	0:45	75.0	41.0	1.0	89	19.6	151
20:03	0:47	75.0	41.0	1.0	90	19.6	151
20:05	0:49	75.0	41.0	1.0	90	17.8	137
20:07	0:51	75.0	41.0	1.0	89	18.4	142
20:09	0:53	75.0	42.0	1.0	90	17.9	138
20:11	0:55	75.0	42.0	1.0	90	19.1	147
20:13	0:57	0.0	0.0	0.0	89	19.1	147
20:15	0:59	74.0	41.0	0.7	89	19.1	147
20:17	1:01	75.0	41.0	1.0	89	21.8	168
20:19	1:03	75.0	42.0	1.0	90	19.7	152
20:21	1:05	75.0	42.0	1.0	90	19.3	149
20:24	1:07	75.0	41.0	1.0	90	18.9	146
20:26	1:09	75.0	41.0	1.0	90	20.1	155
20:28	1:11	75.0	41.0	1.0	90	20.1	155
20:30	1:13	75.0	41.0	1.0	90	18.9	146
Average		75.0	41.4	1.0	89.6	19.7	151.9
Average Test Conditions: SCRN2.XLS				Feed Pressure = 72.5 psig			
				Concentrate Pressure = 39.9 psig			
Date Run: 20-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SpinTek Static Test Cell STC-X4

SCRN3							
0.25 um TiO₂/Al₂O₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
20:41	0:00	46.0	16.0	1.0	90	17.1	132
20:43	0:02	35.0	14.0	0.8	90	8.4	65
20:45	0:04	50.0	16.0	1.0	89	8.4	65
20:47	0:06	54.0	16.0	1.1	89	10.9	84
20:49	0:08	48.0	15.0	1.0	90	10.9	84
20:51	0:10	47.0	14.0	1.0	89	9.1	70
21:27	0:45	47.0	14.0	1.0	90	9.1	70
21:34	0:53	47.0	14.0	1.0	90	9.1	70
21:37	0:56	47.0	14.0	1.0	90	9.1	70
Average		46.8	14.8	1.0	89.7	10.2	79.0
Average Test Conditions: SCRN3.XLS				Feed Pressure = 46.9 psig			
				Concentrate Pressure = 14.6 psig			
Date Run: 20-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN3							
0.25 um TiO ₂ /SiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
20:41	0:00	46.0	16.0	1.0	90	12.4	96
20:43	0:01	35.0	14.0	0.8	90	12.4	96
20:45	0:03	50.0	16.0	1.0	89	7.5	58
20:47	0:06	54.0	16.0	1.1	89	7.5	58
20:49	0:08	48.0	15.0	1.0	90	11.4	88
20:51	0:10	47.0	14.0	1.0	89	11.4	88
21:27	0:45	47.0	14.0	1.0	90	9.2	71
21:34	0:53	47.0	14.0	1.0	90	9.2	71
21:37	0:56	47.0	14.0	1.0	90	9.2	71
Average		46.8	14.8	1.0	89.7	10.0	77.3
Average Test Conditions: SCRN3.XLS				Feed Pressure = 46.9 psig			
				Concentrate Pressure = 14.6 psig			
Date Run: 20-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN3							
0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(°F)	(ml/min)	(gal/ft ² -day)
20:41	0:00	46.0	16.0	1.0	90	10.8	83
20:43	0:01	35.0	14.0	0.8	90	10.8	83
20:45	0:03	50.0	16.0	1.0	89	10.8	83
20:47	0:06	54.0	16.0	1.1	89	10.4	80
20:49	0:08	48.0	15.0	1.0	90	10.6	82
20:51	0:10	47.0	14.0	1.0	89	10.6	82
21:27	0:45	47.0	14.0	1.0	90	10.6	82
21:34	0:53	47.0	14.0	1.0	90	10.6	82
21:37	0:56	47.0	14.0	1.0	90	10.6	82
Average		46.8	14.8	1.0	89.7	10.6	82.1
Average Test Conditions: SCRN3.XLS				Feed Pressure = 46.9 psig			
				Concentrate Pressure = 14.6 psig			
Date Run: 20-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SpinTek Static Test Cell STC-X4

- - - 0.4 um TiO2/Al2O3 — 0.6 um ZrO2 - - 0.3 um ZrO2/TiO2

SCRN4							
0.4 um TiO₂/Al₂O₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
10:01	0:00	75.0	40.0	1.1	89	50.8	392
10:03	0:02	75.0	40.0	1.1	89	52.6	406
10:05	0:04	75.0	40.0	1.1	90	50.0	386
10:07	0:06	74.0	40.0	1.1	90	48.3	373
10:09	0:08	75.0	40.0	1.1	90	47.6	367
10:11	0:10	75.0	40.0	1.1	89	46.1	356
10:13	0:12	74.0	40.0	1.1	90	45.4	350
10:15	0:14	0.0	0.0	0.0	90	45.4	350
10:17	0:16	75.0	40.0	1.1	89	45.4	350
10:19	0:18	75.0	40.0	1.1	89	43.4	335
10:21	0:20	74.0	40.0	1.1	90	44.7	345
10:23	0:22	75.0	40.0	1.1	90	43.4	335
10:25	0:24	74.0	40.0	1.1	90	42.2	326
10:27	0:26	74.0	40.0	1.1	90	42.8	330
10:29	0:28	74.0	40.0	1.1	90	40.0	309
10:31	0:30	0.0	0.0	0.2	89	41.6	321
10:33	0:32	0.0	0.0	0.0	89	41.6	321
10:35	0:34	75.0	40.0	1.1	89	41.6	321
10:37	0:36	75.0	40.0	1.1	90	40.5	313
10:39	0:38	74.0	40.0	1.1	90	41.6	321
10:41	0:40	75.0	40.0	1.1	90	39.4	304
10:43	0:42	75.0	40.0	1.1	89	37.9	292
10:45	0:44	75.0	40.0	1.1	89	37.5	289
10:47	0:46	75.0	41.0	1.1	90	38.9	300
10:49	0:48	75.0	40.0	1.1	90	35.2	272
10:51	0:50	75.0	41.0	1.1	89	37.5	289
10:53	0:52	0.0	0.0	0.0	89	37.5	289
10:55	0:54	75.0	41.0	1.1	89	37.5	289
10:57	0:56	75.0	40.0	1.1	90	36.5	282
10:59	0:58	75.0	41.0	1.1	89	36.5	282
11:01	1:00	75.0	40.0	1.1	90	35.2	272
11:03	1:02	75.0	41.0	1.1	89	34.8	269
11:05	1:04	75.0	40.0	1.1	90	34.4	265
11:07	1:06	75.0	40.0	1.1	89	34.4	265
11:10	1:08	0.0	0.0	0.0	89	33.3	257
11:12	1:10	75.0	40.0	1.1	88	33.3	257
11:14	1:12	75.0	41.0	1.1	90	34.0	262
11:16	1:14	75.0	40.0	1.1	89	34.0	262
11:18	1:16	75.0	41.0	1.1	90	33.3	257
11:20	1:18	75.0	40.0	1.1	90	33.3	257
11:22	1:20	75.0	40.0	1.1	90	32.9	254
11:24	1:22	75.0	41.0	1.1	89	32.9	254
11:26	1:24	75.0	40.0	1.1	90	32.2	248
11:57	1:56	75.0	40.0	1.1	90	32.2	248

0.4 um TiO ₂ /Al ₂ O ₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
11:58	1:56	75.0	40.0	1.1	90	32.2	248
12:00	1:59	75.0	40.0	1.1	90	32.2	248
12:02	2:01	75.0	40.0	1.1	90	32.2	248
12:05	2:03	75.0	40.0	1.1	90	32.2	248
12:06	2:04	75.0	40.0	1.1	90	32.2	248
12:09	2:08	75.0	40.0	1.1	90	32.2	248
12:11	2:09	75.0	40.0	1.1	90	32.2	248
12:15	2:14	75.0	40.0	1.1	90	32.2	248
12:19	2:17	75.0	40.0	1.1	90	32.2	248
Average		74.9	40.2	1.1	89.6	38.1	294.2
Average Test Conditions: SCRN4.XLS				Feed Pressure = 72.9 psig			
				Concentrate Pressure = 39.1 psig			
Date Run: 21-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN4							
0.6 um ZrO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
10:01	0:00	75.0	40.0	1.1	89	52.6	406
10:03	0:02	75.0	40.0	1.1	89	50.8	392
10:05	0:04	75.0	40.0	1.1	90	54.5	421
10:07	0:06	74.0	40.0	1.1	90	48.3	373
10:09	0:08	75.0	40.0	1.1	90	47.6	367
10:11	0:10	75.0	40.0	1.1	89	48.3	373
10:13	0:12	74.0	40.0	1.1	90	48.3	373
10:15	0:14	0.0	0.0	0.0	90	48.3	373
10:17	0:16	75.0	40.0	1.1	89	56.6	437
10:19	0:18	75.0	40.0	1.1	89	48.3	373
10:21	0:20	74.0	40.0	1.1	90	46.1	356
10:23	0:22	75.0	40.0	1.1	90	46.1	356
10:25	0:24	74.0	40.0	1.1	90	45.4	350
10:27	0:26	74.0	40.0	1.1	90	44.7	345
10:29	0:28	74.0	40.0	1.1	90	42.2	326
10:31	0:30	0.0	0.0	0.2	89	42.8	330
10:33	0:32	0.0	0.0	0.0	89	42.8	330
10:35	0:34	75.0	40.0	1.1	89	47.6	367
10:37	0:36	75.0	40.0	1.1	90	44.7	345
10:39	0:38	74.0	40.0	1.1	90	42.2	326
10:41	0:40	75.0	40.0	1.1	90	41.6	321
10:43	0:42	75.0	40.0	1.1	89	40.5	313
10:45	0:44	75.0	40.0	1.1	89	39.4	304
10:47	0:46	75.0	41.0	1.1	90	40.5	313
10:49	0:48	75.0	40.0	1.1	90	39.4	304
10:51	0:50	75.0	41.0	1.1	89	38.9	300
10:53	0:52	0.0	0.0	0.0	89	37.9	292
10:55	0:54	75.0	41.0	1.1	89	37.9	292
10:57	0:56	75.0	40.0	1.1	90	38.9	300
10:59	0:58	75.0	41.0	1.1	89	37.9	292
11:02	1:00	75.0	40.0	1.1	90	37.5	289
11:04	1:02	75.0	41.0	1.1	89	36.5	282
11:06	1:04	75.0	40.0	1.1	90	36.1	279
11:08	1:06	75.0	40.0	1.1	89	36.1	279
11:10	1:08	0.0	0.0	0.0	89	36.1	279
11:12	1:10	75.0	40.0	1.1	88	36.1	279
11:14	1:12	75.0	41.0	1.1	90	36.1	279
11:16	1:14	75.0	40.0	1.1	89	36.1	279
11:18	1:16	75.0	41.0	1.1	90	35.7	275
11:20	1:18	75.0	40.0	1.1	90	35.2	272
11:22	1:20	75.0	40.0	1.1	90	35.2	272
11:24	1:22	75.0	41.0	1.1	89	34.4	265
11:26	1:24	75.0	40.0	1.1	90	34.0	262
11:57	1:56	75.0	40.0	1.1	90	34.0	262

0.6 um ZrO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
11:58	1:56	75.0	40.0	1.1	90	34.0	262
12:00	1:58	75.0	40.0	1.1	90	34.0	262
12:02	2:01	75.0	40.0	1.1	90	34.0	262
12:05	2:03	75.0	40.0	1.1	90	34.0	262
12:06	2:04	75.0	40.0	1.1	90	34.0	262
12:09	2:08	75.0	40.0	1.1	90	34.0	262
12:11	2:09	75.0	40.0	1.1	90	34.0	262
12:15	2:14	75.0	40.0	1.1	90	34.0	262
12:19	2:17	75.0	40.0	1.1	90	34.0	262
Average		74.9	40.2	1.1	89.6	40.4	311.6
Average Test Conditions: SCRN4.XLS				Feed Pressure = 72.9 psig			
				Concentrate Pressure = 39.1 psig			
Date Run: 21-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN4							
0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(°F)	(ml/min)	(gal/ft ² -day)
10:01	0:00	75.0	40.0	1.1	89	17.6	136
10:03	0:02	75.0	40.0	1.1	89	18.9	146
10:05	0:04	75.0	40.0	1.1	90	18.6	144
10:07	0:06	74.0	40.0	1.1	90	18.4	142
10:09	0:08	75.0	40.0	1.1	90	18.7	144
10:11	0:10	75.0	40.0	1.1	89	19.2	148
10:13	0:12	74.0	40.0	1.1	90	16.3	126
10:15	0:14	0.0	0.0	0.0	90	16.3	126
10:17	0:16	75.0	40.0	1.1	89	16.3	126
10:19	0:18	75.0	40.0	1.1	89	17.9	138
10:21	0:20	74.0	40.0	1.1	90	19.1	147
10:23	0:22	75.0	40.0	1.1	90	18.1	140
10:25	0:24	74.0	40.0	1.1	90	18.8	145
10:27	0:26	74.0	40.0	1.1	90	18.8	145
10:29	0:28	74.0	40.0	1.1	90	18.1	140
10:31	0:30	0.0	0.0	0.2	89	18.0	139
10:33	0:32	0.0	0.0	0.0	89	18.0	139
10:35	0:34	75.0	40.0	1.1	89	17.0	131
10:37	0:36	75.0	40.0	1.1	90	18.7	144
10:39	0:38	74.0	40.0	1.1	90	18.8	145
10:41	0:40	75.0	40.0	1.1	90	18.7	144
10:43	0:42	75.0	40.0	1.1	89	18.7	144
10:45	0:44	75.0	40.0	1.1	89	17.6	136
10:47	0:46	75.0	41.0	1.1	90	18.8	145
10:49	0:48	75.0	40.0	1.1	90	18.0	139
10:51	0:50	75.0	41.0	1.1	89	18.4	142
10:53	0:52	0.0	0.0	0.0	89	18.4	142
10:55	0:54	75.0	41.0	1.1	89	1.5	12
10:57	0:56	75.0	40.0	1.1	90	18.7	144
11:00	0:58	75.0	41.0	1.1	89	18.4	142
11:02	1:00	75.0	40.0	1.1	90	18.1	140
11:04	1:02	75.0	41.0	1.1	89	18.0	139
11:06	1:04	75.0	40.0	1.1	90	17.6	136
11:08	1:06	75.0	40.0	1.1	89	17.6	136
11:10	1:08	0.0	0.0	0.0	89	17.9	138
11:12	1:10	75.0	40.0	1.1	88	17.9	138
11:14	1:12	75.0	41.0	1.1	90	16.8	130
11:16	1:14	75.0	40.0	1.1	89	18.5	143
11:18	1:16	75.0	41.0	1.1	90	18.2	140
11:20	1:18	75.0	40.0	1.1	90	18.1	140
11:22	1:20	75.0	40.0	1.1	90	18.0	139
11:24	1:22	75.0	41.0	1.1	89	17.8	137
11:26	1:24	75.0	40.0	1.1	90	17.9	138
11:57	1:56	75.0	40.0	1.1	90	17.9	138

0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
11:58	1:56	75.0	40.0	1.1	90	17.9	138
12:00	1:58	75.0	40.0	1.1	90	17.9	138
12:02	2:01	75.0	40.0	1.1	90	17.9	138
12:05	2:03	75.0	40.0	1.1	90	17.9	138
12:06	2:04	75.0	40.0	1.1	90	17.9	138
12:09	2:08	75.0	40.0	1.1	90	17.9	138
12:11	2:09	75.0	40.0	1.1	90	17.9	138
12:15	2:14	75.0	40.0	1.1	90	17.9	138
12:19	2:17	75.0	40.0	1.1	90	17.9	138
Average		74.9	40.2	1.1	89.6	17.7	136.9
Average Test Conditions: SCRN4.XLS				Feed Pressure = 72.9 psig			
				Concentrate Pressure = 39.1 psig			
Date Run: 21-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SpinTek Static Test Cell STC-X4

SCRN4A							
0.4 um TiO ₂ /Al ₂ O ₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
12:26	0:00	75.0	40.0	1.1	90	28.8	222
12:36	0:09	0.0	0.0	0.0	89	28.3	218
12:46	0:19	75.0	40.0	1.1	89	28.0	216
12:56	0:29	75.0	40.0	1.1	90	28.3	218
13:06	0:39	75.0	40.0	1.1	90	27.2	210
13:16	0:49	75.0	40.0	1.1	90	27.7	214
13:26	0:59	75.0	41.0	1.1	90	26.7	206
13:36	1:09	39.0	21.0	0.1	89	26.3	203
13:46	1:19	75.0	40.0	1.1	90	26.0	201
13:56	1:29	6.0	3.0	0.7	90	25.6	198
14:06	1:39	75.0	41.0	1.1	89	25.6	198
14:16	1:49	75.0	40.0	1.1	90	25.2	194
14:26	1:59	75.0	41.0	1.1	89	25.4	196
14:36	2:09	75.0	40.0	1.1	89	24.5	189
14:46	2:19	75.0	40.0	1.1	89	25.2	194
14:56	2:30	0.0	0.0	0.0	89	24.0	185
15:06	2:39	75.0	40.0	1.1	89	24.1	186
15:16	2:50	75.0	40.0	1.1	89	24.1	186
15:26	3:00	0.0	0.0	0.0	89	23.6	182
15:36	3:10	75.0	40.0	1.1	89	23.8	184
15:46	3:20	75.0	40.0	1.1	90	23.8	184
Average		72.9	39.1	1.0	89.5	25.9	200.1
Average Test Conditions: SCRN4A.XLS				Feed Pressure = 72.9 psig			
				Concentrate Pressure = 39.1 psig			
Date Run: 21-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN4A.XLS

SCRN4A							
0.6 um Zr O ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
12:26	0:00	75.0	40.0	1.1	90	29.7	229
12:36	0:09	0.0	0.0	0.0	89	28.8	222
12:46	0:19	75.0	40.0	1.1	89	29.1	225
12:56	0:29	75.0	40.0	1.1	90	29.4	227
13:06	0:39	75.0	40.0	1.1	90	28.5	220
13:16	0:49	75.0	40.0	1.1	90	28.3	218
13:26	0:59	75.0	41.0	1.1	90	27.5	212
13:36	1:09	39.0	21.0	0.1	89	27.0	208
13:46	1:19	75.0	40.0	1.1	90	27.2	210
13:56	1:29	6.0	3.0	0.7	90	26.5	205
14:06	1:39	75.0	41.0	1.1	89	26.7	206
14:16	1:49	75.0	40.0	1.1	90	26.0	201
14:26	1:59	75.0	41.0	1.1	89	26.0	201
14:36	2:09	75.0	40.0	1.1	89	25.6	198
14:46	2:19	75.0	40.0	1.1	89	25.8	199
14:56	2:29	0.0	0.0	0.0	89	25.2	194
15:06	2:39	75.0	40.0	1.1	89	25.0	193
15:16	2:49	75.0	40.0	1.1	89	25.6	198
15:26	3:00	0.0	0.0	0.0	89	25.0	193
15:36	3:10	75.0	40.0	1.1	89	25.2	194
15:46	3:20	75.0	40.0	1.1	90	24.7	191
Average		72.9	39.1	1.0	89.5	26.9	207.6
Average Test Conditions: SCRN4A.XLS				Feed Pressure = 72.9 psig			
				Concentrate Pressure = 39.1 psig			
Date Run: 21-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SCRN4A							
0.3 um ZrO₂/TiO₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
12:26	0:00	75.0	40.0	1.1	90	17.1	132
12:36	0:09	0.0	0.0	0.0	89	17.3	134
12:46	0:19	75.0	40.0	1.1	89	17.3	134
12:56	0:29	75.0	40.0	1.1	90	17.1	132
13:06	0:39	75.0	40.0	1.1	90	16.9	130
13:16	0:49	75.0	40.0	1.1	90	16.8	130
13:26	0:59	75.0	41.0	1.1	90	16.6	128
13:36	1:09	39.0	21.0	0.1	89	16.3	126
13:46	1:19	75.0	40.0	1.1	90	16.4	127
13:56	1:29	6.0	3.0	0.7	90	16.2	125
14:06	1:39	75.0	41.0	1.1	89	16.3	126
14:16	1:49	75.0	40.0	1.1	90	15.9	123
14:26	1:59	75.0	41.0	1.1	89	16.1	124
14:36	2:09	75.0	40.0	1.1	89	15.8	122
14:46	2:19	75.0	40.0	1.1	89	16.0	123
14:56	2:29	0.0	0.0	0.0	89	15.6	120
15:06	2:39	75.0	40.0	1.1	89	15.6	120
15:16	2:49	75.0	40.0	1.1	89	15.2	117
15:26	3:00	0.0	0.0	0.0	89	15.3	118
15:36	3:10	75.0	40.0	1.1	89	15.6	120
15:46	3:20	75.0	40.0	1.1	90	15.5	120
Average		72.9	39.1	1.0	89.5	16.3	125.5
Average Test Conditions: SCR4A.XLS				Feed Pressure = 72.9 psig			
				Concentrate Pressure = 39.1 psig			
Date Run: 21-Apr-96				Feed Flow = 1.0 gpm			
				Temp. = 90 F			

SpinTek Static Test Cell STC-X4

SCRN5							
0.4 um TiO₂/Al₂O₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
16:22	0:00	29.0	6.0	0.9	89	6.8	52
16:32	0:09	27.0	5.0	0.8	89	7.7	59
16:42	0:19	28.0	5.0	0.8	90	7.6	59
16:52	0:29	29.0	6.0	0.9	90	7.7	59
17:02	0:39	28.0	6.0	0.9	89	6.6	51
17:12	0:49	30.0	6.0	0.9	90	7.9	61
17:22	0:59	29.0	6.0	0.9	90	7.4	57
17:32	1:09	28.0	5.0	0.9	90	7.5	58
Average		28.5	5.6	0.9	89.6	7.4	57.1
Average Test Conditions: SCRN5.XLS				Feed Pressure = 28.5 psig			
				Concentrate Pressure = 5.6 psig			
Date Run: 21-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 90 F			

SCRN5.XLS

SCRN5							
0.6 um ZrO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
16:22	0:00	29.0	6.0	0.9	89	8.4	65
16:32	0:09	27.0	5.0	0.8	89	7.4	57
16:42	0:19	28.0	5.0	0.8	90	8.5	66
16:52	0:29	29.0	6.0	0.9	90	7.7	59
17:02	0:39	28.0	6.0	0.9	89	7.5	58
17:12	0:49	30.0	6.0	0.9	90	8.1	63
17:22	0:59	29.0	6.0	0.9	90	7.8	60
17:32	1:09	28.0	5.0	0.9	90	7.5	58
Average		28.5	5.6	0.9	89.6	7.9	60.7
Average Test Conditions: SCRN5.XLS				Feed Pressure = 28.5 psig			
				Concentrate Pressure = 5.6 psig			
Date Run: 21-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 90 F			

SCRN5							
0.3 um ZrO ₂ /TiO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
16:22	0:00	29.0	6.0	0.9	89	4.9	38
16:32	0:09	27.0	5.0	0.8	89	4.9	38
16:42	0:19	28.0	5.0	0.8	90	4.8	37
16:52	0:29	29.0	6.0	0.9	90	4.3	33
17:02	0:39	28.0	6.0	0.9	89	5.1	39
17:12	0:49	30.0	6.0	0.9	90	4.5	35
17:22	0:59	29.0	6.0	0.9	90	5.0	39
17:32	1:09	28.0	5.0	0.9	90	4.2	32
Average		28.5	5.6	0.9	89.6	4.7	36.4
Average Test Conditions: SCRN5.XLS				Feed Pressure = 28.5 psig			
				Concentrate Pressure = 5.6 psig			
Date Run: 21-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 90 F			

SpinTek Static Test Cell STC-X4

SCRN6							
0.25 um TiO₂/Al₂O₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
18:10	0:00	29.0	7.0	0.9	89	12.1	93
18:20	0:09	30.0	7.0	0.9	89	12.5	96
18:30	0:19	31.0	7.0	0.9	89	13.1	101
18:40	0:29	30.0	7.0	0.9	90	13.5	104
18:50	0:39	31.0	7.0	0.9	89	13.9	107
19:00	0:49	29.0	7.0	0.9	89	12.9	100
19:10	1:00	29.0	7.0	0.9	89	12.6	97
19:20	1:10	30.0	7.0	0.9	90	13.2	102
Average		29.9	7.0	0.9	89.3	13.0	100.1
Average Test Conditions: SCRN6.XLS				Feed Pressure = 29.9 psig			
				Concentrate Pressure = 7.0 psig			
Date Run: 21-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 89.3 F			

SCRN6.XLS

SCRN6							
0.25 um TiO₂/SiO₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
18:10	0:00	29.0	7.0	0.9	89	11.5	89
18:20	0:09	30.0	7.0	0.9	89	14.2	110
18:30	0:19	31.0	7.0	0.9	89	14.2	110
18:40	0:29	30.0	7.0	0.9	90	14.2	110
18:50	0:39	31.0	7.0	0.9	89	13.8	106
19:00	0:49	29.0	7.0	0.9	89	13.7	106
19:10	1:00	29.0	7.0	0.9	89	13.3	103
19:20	1:10	30.0	7.0	0.9	90	13.8	106
Average		29.9	7.0	0.9	89.3	13.6	104.9
Average Test Conditions: SCRN6.XLS				Feed Pressure = 29.9 psig			
				Concentrate Pressure = 7.0 psig			
Date Run: 21-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 89.3 F			

SCRN6							
0.3 um ZrO₂/TiO₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
18:10	0:00	29.0	7.0	0.9	89	8.4	65
18:20	0:09	30.0	7.0	0.9	89	13.4	103
18:30	0:19	31.0	7.0	0.9	89	14.2	110
18:40	0:29	30.0	7.0	0.9	90	12.3	95
18:50	0:39	31.0	7.0	0.9	89	14.0	108
19:00	0:49	29.0	7.0	0.9	89	11.8	91
19:10	1:00	29.0	7.0	0.9	89	13.3	103
19:20	1:10	30.0	7.0	0.9	90	12.4	96
Average		29.9	7.0	0.9	89.3	12.5	96.3
Average Test Conditions: SCRN6.XLS				Feed Pressure = 29.9 psig			
				Concentrate Pressure = 7.0 psig			
Date Run: 21-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 89.3 F			

SpinTek Static Test Cell STC-X4

- - - 0.4 um TiO2 / Al2O3 — 0.6 um ZrO2 - - - 0.3 um ZrO2 / TiO2

ELAPSED TIME (DD:HH:MM)

SCRN7							
0.4 um TiO₂ / Al₂O₃							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
21:01	0:00	32.0	6.0	0.9	90	10.2	79
21:11	0:09	31.0	6.0	0.9	89	12.0	93
21:21	0:19	28.0	6.0	0.9	90	10.1	78
21:31	0:29	29.0	6.0	0.9	90	10.0	77
21:41	0:39	28.0	6.0	0.9	90	11.1	86
21:51	0:49	27.0	6.0	0.9	90	10.6	82
Average		29.2	6.0	0.9	89.8	10.7	82.3
Average Test Conditions: SCRN7.XLS				Feed Pressure = 29.2 psig			
				Concentrate Pressure = 6.0 psig			
Date Run: 22-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 89.8			

SCRN7.XLS

SCRN7							
0.6 um ZrO ₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
21:01	0:00	32.0	6.0	0.9	90	12.8	99
21:11	0:09	31.0	6.0	0.9	89	9.0	69
21:21	0:19	28.0	6.0	0.9	90	9.4	73
21:31	0:29	29.0	6.0	0.9	90	9.9	76
21:41	0:39	28.0	6.0	0.9	90	10.6	82
21:51	0:49	27.0	6.0	0.9	90	9.7	75
Average		29.2	6.0	0.9	89.8	10.2	79.0
Average Test Conditions: SCRN7.XLS				Feed Pressure = 29.2 psig			
				Concentrate Pressure = 6.0 psig			
Date Run: 22-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 89.8			

SCRN7							
0.3 um ZrO₂ / TiO₂							
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	CONC PRESSURE	FEED FLOW (L/min)	FEED TEMP	PERMEATE FLOW	PERMEATE FLUX
	(HH:MM)	(psig)	(psig)	(gpm)	(° F)	(ml/min)	(gal/ft ² -day)
21:01	0:00	32.0	6.0	0.9	90	12.1	93
21:11	0:09	31.0	6.0	0.9	89	7.4	57
21:21	0:19	28.0	6.0	0.9	90	9.2	71
21:31	0:29	29.0	6.0	0.9	90	9.0	69
21:41	0:39	28.0	6.0	0.9	90	9.6	74
21:51	0:49	27.0	6.0	0.9	90	9.5	73
Average		29.2	6.0	0.9	89.8	9.5	73.1
Average Test Conditions: SCRN7.XLS				Feed Pressure = 29.2 psig			
				Concentrate Pressure = 6.0 psig			
Date Run: 22-Apr-96				Feed Flow = 0.9 gpm			
				Temp. = 89.8			

*Energy &
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Research
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APPENDIX C
PERFORMANCE EVALUATION TEST DATA

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
17:21	0:00	44	88	527	1995	601	431.4		
17:23	0:02	44	91	543	2004	588	422.1		
17:25	0:04	50	91	572	2006	532	381.9		
17:27	0:06	45	89	511	1990	538	386.2		
17:29	0:08	49	90	539	1997	582	417.8		
17:31	0:10	43	92	534	1995	528	379.0		
17:34	0:12	43	90	524	1995	523	375.4		
17:36	0:14	42	89	533	1990	547	392.7		
17:38	0:16	49	91	538	2003	539	386.9		
17:40	0:18	44	91	472	1999	501	359.6		
17:42	0:20	49	90	475	2007	526	377.6		
17:44	0:22	46	91	531	1991	539	386.9		
17:46	0:24	49	91	494	2000	476	341.7		
17:48	0:26	43	89	527	1998	516	370.4		
17:50	0:28	46	90	514	1999	526	377.6		
17:52	0:30	46	89	505	1995	526	377.6		
17:54	0:32	47	91	514	1996	520	373.3		
17:56	0:34	46	89	487	1991	512	367.5		
17:58	0:36	47	89	511	1989	525	376.9		
18:00	0:38	45	91	514	1989	489	351.0		
18:02	0:40	47	89	502	1997	505	362.5		
18:04	0:42	42	90	509	1996	544	390.5		
18:06	0:44	44	90	537	1991	495	355.3		
18:08	0:46	45	89	493	1996	511	366.8		
18:10	0:48	46	89	545	1988	527	378.3		
18:12	0:50	47	92	523	1991	487	349.6		
18:14	0:52	48	90	515	1997	474	340.3		
18:16	0:54	52	89	483	1987	505	362.5		
18:18	0:56	50	90	509	1989	519	372.6		
18:20	0:58	45	91	506	2003	504	361.8		
18:22	1:00	51	89	507	2003	489	351.0		
18:24	1:02	43	89	507	1990	512	367.5		
18:26	1:04	43	91	513	2003	459	329.5		
18:28	1:06	46	89	524	1995	489	351.0		
18:30	1:08	49	89	521	1991	510	366.1		
18:32	1:10	46	91	523	1996	496	356.0		
18:34	1:12	48	90	487	1987	469	336.7		
18:36	1:14	43	89	514	1997	496	356.0		
18:38	1:16	49	90	514	1996	523	375.4		
18:40	1:18	44	90	498	1999	430	308.7		
18:42	1:20	43	89	478	1985	466	334.5	Begin Steady-state	
18:44	1:22	38	90	489	1989	466	334.5		
18:46	1:24	41	90	510	1998	444	318.7		
18:48	1:26	47	90	547	1986	457	328.0		
18:50	1:28	47	90	512	1996	478	343.1		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
18:52	1:30	44	90	515	1996	433	310.8		
18:54	1:32	46	89	543	1985	462	331.6		
18:56	1:34	40	90	528	1995	478	343.1		
18:58	1:36	43	90	524	1987	436	313.0		
19:00	1:38	42	89	508	1997	466	334.5		
19:02	1:40	44	90	504	1992	469	336.7		
19:04	1:42	45	90	504	1992	434	311.5		
19:06	1:44	44	89	486	1987	451	323.7		
19:08	1:46	44	90	481	1990	484	347.4		
19:10	1:48	41	91	526	1990	418	300.1		
19:12	1:50	45	89	532	1995	445	319.4		
19:14	1:52	44	90	516	1989	477	342.4		
19:16	1:54	48	91	499	1990	424	304.4		
19:18	1:56	41	90	521	1998	442	317.3		
19:20	1:58	42	89	509	1993	447	320.9		
19:22	2:00	43	92	505	1987	434	311.5		
19:24	2:02	44	90	500	1996	433	310.8		
19:26	2:04	47	89	487	1996	443	318.0		
19:28	2:06	41	91	510	1994	462	331.6		
19:30	2:08	41	90	524	1986	412	295.7		
19:32	2:10	42	89	489	2000	437	313.7		
19:34	2:12	44	90	528	1990	451	323.7		
19:36	2:14	43	90	538	1998	420	301.5		
19:38	2:16	41	89	509	1986	441	316.6		
19:40	2:18	49	90	462	1993	459	329.5		
19:42	2:20	43	91	482	1990	422	302.9		
19:44	2:22	48	90	553	1998	440	315.8		
19:46	2:24	46	90	529	1998	447	320.9		
19:48	2:26	43	91	466	1984	420	301.5		
19:50	2:28	43	89	473	1987	447	320.9		
19:52	2:31	47	90	470	1993	463	332.4		
19:54	2:33	48	90	494	1996	415	297.9		
19:56	2:35	41	89	526	1987	451	323.7		
19:58	2:37	42	90	527	1988	450	323.0		
20:00	2:39	47	90	475	1989	421	302.2		
20:02	2:41	42	89	531	1996	446	320.2		
20:04	2:43	43	90	542	1988	441	316.6		
20:06	2:45	47	91	482	1986	417	299.3		
20:08	2:47	43	89	504	1996	405	290.7		
20:10	2:49	48	89	535	1985	436	313.0		
20:12	2:51	44	91	527	2003	435	312.3		
20:14	2:53	45	89	513	1989	407	292.2		
20:16	2:55	47	89	566	1983	446	320.2		
20:18	2:57	44	91	486	1999	428	307.2		
20:20	2:59	43	90	502	1984	397	285.0		
20:23	3:01	45	89	509	1987	439	315.1		
20:25	3:03	43	90	491	1989	449	322.3		
20:27	3:05	41	91	539	1993	406	291.4		
20:29	3:07	42	89	517	1988	434	311.5		
20:31	3:09	44	91	485	1987	455	326.6		

MATR_1.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
20:33	3:11	44	91	511	1988	412	295.7		
20:35	3:13	40	89	470	1986	428	307.2		
20:37	3:15	43	90	503	1985	432	310.1		
20:39	3:17	41	91	490	1992	424	304.4		
20:41	3:19	44	90	524	1986	421	302.2	End Steady-state	
Steady-state Avg.		44	90	508	1991	440	316		
Maximum		49	92	566	2003	484	347		
Minimum		38	89	462	1983	397	285		
Standard Deviation		2.4	0.8	23.5	4.9	20.1	14.4		
TEST CONDITIONS: MATR_1.XLS				Temp.= 90 F					
				Press. = 45 psig					
Date Run: 9-May-96				Rotor = 2000 rpm					
				Solids = 15 wt%					
				Flow = 500 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
17:15	0:00	75	120	475	1501	630	452.2	Begin Steady-state	
17:17	0:01	75	120	455	1507	616	442.2		
17:19	0:03	75	120	515	1500	555	398.4		
17:21	0:05	77	118	501	1500	595	427.1		
17:23	0:07	73	118	484	1508	609	437.2		
17:25	0:09	76	118	492	1496	584	419.2		
17:27	0:12	73	119	455	1498	602	432.1		
17:29	0:14	74	120	455	1504	629	451.5		
17:31	0:16	73	120	479	1506	615	441.5		
17:33	0:18	79	119	485	1495	549	394.1		
17:36	0:20	73	117	440	1506	605	434.3		
17:37	0:22	80	118	464	1500	588	422.1		
17:40	0:24	80	118	442	1499	620	445.1		
17:41	0:26	73	118	428	1503	601	431.4		
17:44	0:28	74	119	497	1503	577	414.2		
17:45	0:30	78	120	481	1503	605	434.3		
17:48	0:32	74	120	433	1507	603	432.9		
17:50	0:34	76	120	484	1504	624	447.9		
17:52	0:36	74	118	450	1497	565	405.6		
17:54	0:38	71	117	455	1500	589	422.8		
17:56	0:40	75	118	458	1495	583	418.5		
17:58	0:42	76	117	447	1500	593	425.7		
18:00	0:44	78	118	466	1496	610	437.9		
18:02	0:46	72	118	514	1504	587	421.4		
18:04	0:48	72	118	504	1504	597	428.5		
18:06	0:50	72	119	449	1499	606	435.0		
18:08	0:52	72	120	479	1499	603	432.9		
18:10	0:54	70	120	449	1506	618	443.6		
18:12	0:56	75	120	516	1507	558	400.5		
18:14	0:58	74	117	499	1504	585	419.9		
18:16	1:00	71	117	449	1502	601	431.4		
18:18	1:02	73	118	456	1499	566	406.3		
18:20	1:04	75	118	509	1504	602	432.1		
18:22	1:06	74	119	461	1503	600	430.7		
18:24	1:08	73	119	445	1504	606	435.0		
18:26	1:10	74	119	458	1496	615	441.5		
18:28	1:12	71	120	491	1500	607	435.7		
18:30	1:14	77	119	485	1505	529	379.7		
18:32	1:16	72	117	406	1496	599	430.0		
18:34	1:18	75	118	484	1497	580	416.3		
18:36	1:20	78	118	482	1506	586	420.6		
18:38	1:22	72	118	442	1509	610	437.9		
18:40	1:24	72	119	480	1501	604	433.6		
18:42	1:26	74	119	509	1503	623	447.2		
18:44	1:28	75	120	421	1500	623	447.2		

MATR_2.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
18:46	1:30	76	120	478	1503	617	442.9		
18:48	1:32	79	119	513	1496	521	374.0		
18:50	1:34	73	117	464	1494	586	420.6		
18:52	1:36	72	117	489	1504	610	437.9		
18:54	1:38	76	117	454	1503	597	428.5		
18:56	1:40	71	118	480	1496	590	423.5		
18:58	1:42	77	119	428	1503	613	440.0		
19:00	1:44	75	120	453	1496	603	432.9		
19:02	1:46	74	120	554	1510	563	404.1		
19:04	1:48	73	118	484	1503	582	417.8		
19:06	1:50	78	117	448	1504	605	434.3		
19:08	1:52	73	118	475	1508	604	433.6		
19:10	1:54	74	119	408	1496	613	440.0		
19:12	1:56	76	119	514	1503	610	437.9		
19:14	1:58	76	120	389	1507	599	430.0		
19:16	2:00	74	118	507	1504	543	389.8		
19:18	2:02	74	117	503	1496	584	419.2		
19:20	2:04	75	117	481	1493	602	432.1		
19:22	2:06	77	118	447	1500	596	427.8		
19:24	2:08	73	119	501	1496	601	431.4		
19:26	2:10	76	119	426	1496	621	445.8		
19:28	2:12	75	120	489	1502	600	430.7		
19:30	2:14	75	119	496	1503	545	391.2		
19:32	2:16	76	117	411	1488	587	421.4		
19:34	2:18	79	118	427	1503	585	419.9		
19:36	2:20	74	118	488	1505	584	419.2	End Steady-state	
Steady-state Avg.		75	119	470	1501	595	427		
Maximum		80	120	554	1510	630	452		
Minimum		70	117	389	1488	521	374		
Standard Deviation		2.3	1.1	31.5	4.4	22.7	16.3		
TEST CONDITIONS: MATR_2.XLS				Temp. = 120 F					
				Press. = 75 psig					
Date Run: 10-May-96				Rotor = 1500 rpm					
				Solids = 15 wt%					
				Flow = 500 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
12:04	0:00	66	90	467	995	961	689.8		
12:06	0:02	59	91	483	997	970	696.3		
12:08	0:04	62	91	472	997	952	683.4		
12:11	0:06	60	91	476	995	922	661.8		
12:13	0:08	63	90	477	995	924	663.3		
12:15	0:10	67	90	477	995	933	669.7		
12:17	0:12	67	91	478	996	910	653.2		
12:19	0:14	67	90	480	998	880	631.7		
12:21	0:16	59	89	474	997	916	657.5		
12:23	0:18	59	91	478	997	899	645.3		
12:25	0:20	64	90	480	996	841	603.7		
12:27	0:22	58	89	485	997	879	631.0		
12:29	0:24	60	90	483	997	895	642.5		
12:31	0:26	64	91	487	995	872	625.9		
12:33	0:28	65	90	485	996	874	627.4		
12:35	0:30	56	90	491	995	843	605.1		
12:37	0:32	62	90	494	996	815	585.0		
12:39	0:34	60	90	486	995	818	587.2		
12:41	0:36	60	90	497	997	839	602.3		
12:43	0:38	57	91	491	997	818	587.2		
12:45	0:40	64	90	489	997	793	569.2		
12:47	0:42	56	89	499	995	820	588.6		
12:49	0:44	63	90	495	996	833	598.0		
12:51	0:46	60	91	491	995	776	557.0		
12:53	0:48	57	89	495	995	795	570.7		
12:55	0:50	63	89	494	993	821	589.3		
12:57	0:52	61	90	486	996	823	590.8		
12:59	0:54	61	90	492	996	760	545.5		
13:01	0:56	64	89	492	994	811	582.2		
13:03	0:58	61	90	492	997	826	592.9		
13:05	1:00	61	90	486	996	780	559.9		
13:07	1:02	57	89	488	994	784	562.8		
13:09	1:04	59	89	486	994	806	578.6		
13:11	1:06	60	90	482	996	773	554.9		
13:13	1:08	59	89	495	998	759	544.8		
13:15	1:10	61	89	488	994	796	571.4		
13:17	1:12	61	90	487	996	803	576.4		
13:19	1:14	63	90	487	996	764	548.4		
13:21	1:16	59	89	487	994	783	562.1		
13:23	1:18	59	89	487	996	794	570.0		
13:25	1:20	63	90	483	993	774	555.6		
13:27	1:22	60	89	491	997	757	543.4		
13:29	1:24	65	89	496	994	788	565.6		
13:31	1:26	60	90	489	995	795	570.7		
13:33	1:28	59	90	490	1006	736	528.3		

MATR_3.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
13:35	1:30	61	89	496	995	722	518.3		
13:37	1:32	61	89	496	994	810	581.4		
13:39	1:34	58	90	487	995	754	541.2		
13:41	1:36	61	89	499	995	765	549.1		
13:43	1:38	61	90	492	997	789	566.4		
13:45	1:40	61	90	488	993	778	558.5		
13:47	1:42	59	89	483	993	713	511.8		
13:49	1:44	58	89	496	995	761	546.3	Begin Steady-state	
13:51	1:46	61	90	500	992	776	557.0		
13:53	1:48	57	90	482	993	719	516.1		
13:55	1:50	63	89	482	995	757	543.4		
13:57	1:52	61	89	484	993	770	552.7		
13:59	1:54	61	90	487	999	779	559.2		
14:01	1:56	61	90	475	997	716	514.0		
14:03	1:58	62	89	497	993	751	539.1		
14:05	2:00	60	89	488	995	766	549.9		
14:07	2:02	63	91	490	996	732	525.5		
14:09	2:04	61	89	496	993	754	541.2		
14:11	2:06	61	89	492	996	757	543.4		
14:13	2:08	63	90	482	992	778	558.5		
14:15	2:10	58	90	495	995	723	519.0		
14:17	2:12	63	89	492	998	750	538.4		
14:19	2:14	62	89	482	997	763	547.7		
14:21	2:16	62	90	498	995	730	524.0		
14:23	2:18	58	89	493	994	741	531.9		
14:25	2:20	60	89	476	994	761	546.3		
14:27	2:22	58	90	490	999	770	552.7		
14:29	2:24	63	90	478	995	725	520.4		
14:31	2:26	58	89	499	995	744	534.1		
14:33	2:28	61	89	500	995	750	538.4		
14:35	2:30	62	90	490	996	725	520.4		
14:37	2:32	59	89	477	994	717	514.7		
14:39	2:34	65	89	494	994	737	529.0		
14:41	2:36	57	90	496	994	760	545.5		
14:43	2:38	66	91	475	993	722	518.3		
14:45	2:40	61	89	491	993	745	534.8		
14:47	2:42	61	89	499	993	755	542.0		
14:49	2:45	63	90	495	992	702	503.9		
14:51	2:47	61	89	486	996	736	528.3		
14:53	2:49	63	89	489	994	749	537.7		
14:55	2:51	60	90	490	994	734	526.9		
14:57	2:53	61	89	484	995	698	501.0		
15:00	2:55	63	89	485	996	736	528.3		
15:01	2:57	60	90	482	994	741	531.9		
15:04	2:59	58	90	493	998	697	500.3		
15:06	3:01	59	89	486	992	724	519.7		
15:08	3:03	62	89	497	991	738	529.8		
15:10	3:05	62	90	486	996	699	501.8		
15:12	3:07	62	89	483	996	711	510.4		
15:14	3:09	58	89	492	995	724	519.7		

MATR_3.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
15:16	3:11	60	90	480	997	737	529.0		
15:18	3:13	59	90	483	995	688	493.9		
15:20	3:15	64	89	497	994	730	524.0		
15:22	3:17	57	89	492	994	732	525.5		
15:24	3:19	58	90	486	997	715	513.2		
15:26	3:21	65	90	491	994	682	489.6		
15:28	3:23	61	89	485	992	721	517.6		
15:30	3:25	62	90	485	996	736	528.3		
15:32	3:27	63	91	482	997	697	500.3		
15:34	3:29	62	89	480	995	719	516.1		
15:36	3:31	61	89	487	992	735	527.6		
15:38	3:33	59	90	487	995	734	526.9	End Steady-state	
Steady-State Avg.		61	90	488	995	735	528		
Maximum		66	91	500	999	779	559		
Minimum		57	89	475	991	682	490		
Standard Deviation		2.2	0.6	6.8	1.8	23.3	16.7		
TEST CONDITIONS: MATR_3.XLS				Temp. = 90 F					
				Press. = 60 psig					
Date Run: 11-May-96				Rotor = 1000 rpm					
				Solids = 1 wt%					
				Flow = 500 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
7:54	0:00	62	88	510	1995	377	270.6		
7:56	0:02	60	88	511	2006	397	285.0		
7:58	0:04	58	88	512	2001	402	288.6		
8:00	0:06	60	88	512	1997	383	274.9		
8:02	0:08	60	89	512	2000	390	280.0		
8:04	0:10	63	89	509	1997	404	290.0		
8:06	0:12	62	94	507	2005	378	271.3		
8:08	0:14	58	93	508	2004	365	262.0		
8:10	0:16	61	93	508	1997	356	255.5		
8:12	0:18	62	92	510	2000	367	263.4		
8:14	0:20	60	91	506	1996	327	234.7		
8:16	0:22	59	91	504	1995	339	243.3		
8:18	0:24	57	90	504	1992	340	244.1		
8:20	0:26	58	88	507	1997	363	260.6		
8:22	0:28	57	88	505	1992	370	265.6		
8:24	0:30	60	89	506	1996	370	265.6		
8:26	0:32	58	90	506	1990	391	280.7		
8:28	0:34	58	90	504	1990	372	267.0		
8:30	0:36	59	91	503	1996	355	254.8		
8:32	0:38	57	90	502	2001	337	241.9		
8:34	0:40	59	90	501	1989	343	246.2		
8:36	0:42	59	90	503	1989	357	256.3		
8:38	0:44	61	89	503	1995	373	267.8		
8:40	0:46	57	91	501	1996	349	250.5	Begin Steady-state	
8:42	0:48	58	90	502	1995	335	240.5		
8:44	0:50	58	90	499	1994	334	239.8		
8:46	0:52	57	89	500	1994	354	254.1		
8:48	0:54	60	89	501	1998	360	258.4		
8:50	0:56	57	89	504	1997	358	257.0		
8:52	0:58	57	90	499	1994	378	271.3		
8:54	1:00	59	91	501	1993	353	253.4		
8:56	1:02	58	91	495	1992	329	236.2		
8:58	1:04	57	90	498	2005	326	234.0		
9:00	1:06	59	90	495	1990	346	248.4		
9:02	1:08	60	89	497	1993	358	257.0		
9:04	1:10	60	89	496	1996	363	260.6		
9:06	1:12	60	90	497	1991	362	259.9		
9:08	1:14	61	89	499	2001	360	258.4		
9:10	1:16	57	91	499	1994	377	270.6		
9:12	1:18	58	91	496	1989	350	251.2		
9:14	1:20	56	91	495	2006	340	244.1		
9:16	1:22	57	90	497	1992	315	226.1		
9:18	1:24	59	89	494	1996	345	247.7		
9:20	1:26	61	90	494	1991	364	261.3		
9:22	1:28	61	89	498	1988	381	273.5		
9:24	1:30	60	90	494	1981	361	259.1		

MATR_4.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
9:26	1:32	56	90	493	1990	372	267.0		
9:28	1:34	56	91	494	1991	335	240.5		
9:30	1:36	56	91	495	2000	333	239.0		
9:32	1:38	57	90	492	1990	321	230.4		
9:34	1:40	58	89	494	1988	349	250.5		
9:36	1:42	57	89	495	1994	358	257.0		
9:38	1:44	54	89	489	1996	374	268.5		
9:40	1:46	55	89	494	1988	372	267.0		
9:42	1:48	59	90	483	1987	395	283.5		
9:44	1:50	60	91	482	1985	353	253.4		
9:46	1:52	65	92	484	1996	335	240.5		
9:48	1:54	60	91	480	1989	340	244.1		
9:50	1:56	59	89	481	1998	350	251.2		
9:52	1:58	65	89	484	1993	362	259.9		
9:54	2:00	61	89	482	1994	375	269.2		
9:56	2:02	60	90	481	1996	376	269.9		
9:58	2:04	62	89	482	1986	388	278.5		
10:01	2:07	60	90	482	1989	378	271.3		
10:03	2:09	65	91	481	1993	348	249.8		
10:05	2:11	61	91	481	1985	326	234.0		
10:07	2:13	63	90	479	1979	324	232.6		
10:09	2:15	62	90	482	1994	325	233.3		
10:11	2:17	61	87	480	1988	361	259.1		
10:13	2:19	62	88	478	1982	370	265.6		
10:15	2:21	61	88	480	1992	370	265.6		
10:17	2:23	61	90	480	1989	371	266.3		
10:19	2:25	62	90	482	1992	379	272.1		
10:21	2:27	61	91	480	1986	360	258.4		
10:23	2:29	60	91	480	1994	330	236.9		
10:25	2:31	65	91	482	1992	324	232.6		
10:27	2:33	65	91	479	1986	324	232.6		
10:29	2:35	64	90	479	1997	351	252.0		
10:31	2:37	61	89	480	1988	349	250.5		
10:33	2:39	60	88	482	1987	360	258.4		
10:35	2:41	61	89	482	1987	371	266.3		
10:37	2:43	61	89	482	1998	375	269.2		
10:39	2:45	63	90	481	1988	381	273.5		
10:41	2:47	65	91	476	1990	349	250.5		
10:43	2:49	61	90	477	1990	322	231.1		
10:45	2:51	59	89	478	1996	311	223.2		
10:47	2:53	61	89	477	1983	340	244.1		
10:49	2:55	61	89	479	1977	366	262.7		
10:51	2:57	61	89	479	1982	357	256.3		
10:53	2:59	61	90	477	1991	378	271.3		
10:55	3:01	63	90	476	1985	329	236.2	End Steady-state	

MATR_4.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
Steady-state Avg.		60	90	488	1991	353	254		
Maximum		65	92	504	2006	395	284		
Minimum		54	87	476	1977	311	223		
Standard Deviation		2.6	1.0	8.7	5.6	19.9	14.3		
TEST CONDITIONS: MATR_4.XLS				Temp. =	90 F				
				Press. =	60 psig				
Date Run: 12-May-96				Rotor =	2000 rpm				
				Solids =	30 wt%				
				Flow =	500 L/hr				

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
0:54	0:00	50	91	482	1004	311	223.2		
0:56	0:02	49	89	500	987	321	230.4		
0:58	0:04	44	91	471	998	303	217.5		
1:00	0:06	44	91	482	1000	291	208.9		
1:02	0:08	44	90	445	990	293	210.3		
1:04	0:10	46	90	470	990	290	208.2		
1:06	0:12	49	91	464	989	290	208.2		
1:08	0:14	47	90	485	992	292	209.6		
1:10	0:16	54	90	489	989	326	234.0		
1:12	0:18	45	90	484	995	280	201.0		
1:14	0:20	46	90	446	987	280	201.0		
1:16	0:22	43	91	470	990	280	201.0		
1:18	0:24	46	91	486	984	273	196.0		
1:20	0:26	43	89	478	990	274	196.7		
1:22	0:28	47	90	482	985	281	201.7		
1:24	0:30	46	89	472	984	281	201.7		
1:26	0:32	44	90	484	990	278	199.6		
1:28	0:34	45	90	463	990	278	199.6		
1:30	0:36	48	90	492	990	280	201.0		
1:32	0:38	44	91	516	983	277	198.8		
1:34	0:40	43	90	493	990	264	189.5		
1:36	0:42	46	89	483	988	271	194.5	Begin Steady-state	
1:38	0:44	43	90	484	987	273	196.0		
1:40	0:46	48	89	458	989	272	195.2		
1:43	0:48	46	90	464	996	275	197.4		
1:45	0:50	44	90	467	991	273	196.0		
1:47	0:52	44	90	485	985	273	196.0		
1:49	0:54	43	90	493	986	266	190.9		
1:51	0:56	43	90	470	983	265	190.2		
1:53	0:58	48	89	487	988	270	193.8		
1:55	1:00	47	90	469	1000	270	193.8		
1:57	1:02	48	90	502	988	261	187.4		
1:59	1:04	43	90	467	985	278	199.6		
2:01	1:06	44	90	492	991	264	189.5		
2:03	1:08	43	89	510	993	265	190.2		
2:05	1:10	46	89	472	987	273	196.0		
2:07	1:12	47	90	465	987	273	196.0		
2:09	1:14	45	90	477	987	276	198.1		
2:11	1:16	45	90	468	982	273	196.0		
2:13	1:18	43	90	490	987	269	193.1		
2:15	1:20	46	90	489	983	273	196.0		
2:17	1:22	42	90	490	984	264	189.5		
2:19	1:24	43	90	487	987	273	196.0		
2:21	1:26	43	90	486	984	268	192.4		
2:23	1:28	44	91	497	985	260	186.6		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
2:25	1:30	45	90	486	983	260	186.6		
2:27	1:32	43	90	459	992	270	193.8		
2:29	1:34	44	90	466	983	266	190.9		
2:31	1:36	46	90	496	986	267	191.7		
2:33	1:38	46	90	480	991	272	195.2		
2:35	1:40	45	90	505	987	261	187.4		
2:37	1:42	42	90	483	983	269	193.1		
2:39	1:44	42	89	450	985	266	190.9		
2:41	1:46	43	90	460	987	265	190.2		
2:43	1:48	42	90	479	987	266	190.9		
2:45	1:50	45	89	497	984	261	187.4		
2:47	1:52	46	89	469	985	269	193.1		
2:49	1:54	42	90	471	983	267	191.7		
2:51	1:56	43	90	469	985	269	193.1		
2:53	1:58	42	90	487	984	270	193.8		
2:55	2:00	42	90	446	985	266	190.9		
2:57	2:02	42	90	477	986	263	188.8		
2:59	2:04	46	90	474	982	271	194.5		
3:01	2:06	44	90	499	983	278	199.6		
3:03	2:08	48	90	494	983	276	198.1		
3:05	2:10	45	91	486	983	266	190.9		
3:07	2:12	44	90	446	983	270	193.8		
3:09	2:14	43	89	502	982	281	201.7		
3:11	2:16	43	89	473	984	282	202.4		
3:13	2:18	47	89	484	983	266	190.9		
3:15	2:20	48	90	481	986	267	191.7		
3:17	2:22	48	91	487	983	275	197.4		
3:19	2:24	47	90	460	988	274	196.7		
3:21	2:26	48	90	474	982	284	203.9		
3:23	2:28	49	90	477	979	278	199.6		
3:25	2:30	47	91	490	986	273	196.0		
3:27	2:32	43	90	459	984	259	185.9		
3:29	2:35	47	89	494	982	265	190.2		
3:31	2:36	45	89	480	995	275	197.4		
3:33	2:39	43	89	491	983	264	189.5		
3:35	2:41	45	89	493	982	269	193.1		
3:37	2:43	47	89	477	983	276	198.1		
3:39	2:45	47	90	496	983	276	198.1		
3:41	2:47	46	90	464	983	265	190.2		
3:43	2:49	48	90	464	983	263	188.8		
3:45	2:51	47	89	494	981	272	195.2		
3:47	2:53	43	90	481	982	263	188.8		
3:49	2:55	48	90	487	986	265	190.2	End Steady-state	

MATR_5.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
Steady-state Avg.		45	90	480	986	270	193		
Maximum		49	91	510	1000	284	204		
Minimum		42	89	446	979	259	186		
Standard Deviation		2.1	0.5	14.4	3.8	5.6	4.0		
TEST CONDITIONS: MATR_5.XLS				Temp. =	90 F				
				Press. =	45 psig				
Date Run: 13-May-96				Rotor =	1000 rpm				
				Solids =	15 wt%				
				Flow =	500 L/hr				

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
15:30	0:00	81	89	381	1499	852	611.6		
15:32	0:02	75	89	391	1507	852	611.6		
15:34	0:04	78	89	382	1508	858	615.9		
15:36	0:06	83	89	382	1506	866	621.6		
15:38	0:08	82	90	390	1496	821	589.3		
15:40	0:10	79	90	406	1499	798	572.8		
15:42	0:12	82	89	394	1500	813	583.6		
15:44	0:14	67	90	446	1505	730	524.0		
15:46	0:16	71	91	412	1496	732	525.5		
15:48	0:18	73	91	443	1503	730	524.0		
15:50	0:20	72	91	410	1496	732	525.5		
15:52	0:22	73	90	448	1503	715	513.2		
15:54	0:24	70	91	407	1507	755	542.0		
15:56	0:26	75	89	430	1512	767	550.6		
15:58	0:28	75	90	423	1499	721	517.6		
16:00	0:30	77	90	403	1507	754	541.2		
16:02	0:32	73	90	436	1497	761	546.3		
16:04	0:34	79	91	416	1504	747	536.2		
16:06	0:36	75	91	414	1505	726	521.1		
16:08	0:38	79	88	446	1505	745	534.8		
16:10	0:40	78	89	417	1506	747	536.2		
16:12	0:42	78	89	421	1493	768	551.3		
16:14	0:44	79	90	448	1497	767	550.6		
16:16	0:46	75	91	424	1499	708	508.2		
16:18	0:48	74	91	458	1501	715	513.2		
16:20	0:50	73	90	429	1494	720	516.8		
16:22	0:52	75	91	456	1502	721	517.6		
16:24	0:54	73	91	454	1503	695	498.9		
16:26	0:56	70	89	421	1495	691	496.0		
16:28	0:58	75	89	445	1503	691	496.0		
16:30	1:00	75	90	447	1491	713	511.8		
16:32	1:02	69	89	417	1513	715	513.2		
16:34	1:04	72	90	457	1503	707	507.5		
16:36	1:06	75	90	442	1500	738	529.8		
16:38	1:08	73	90	428	1506	706	506.8		
16:40	1:10	73	91	461	1504	722	518.3		
16:42	1:12	72	89	421	1493	703	504.6		
16:44	1:14	71	89	441	1505	710	509.7		
16:46	1:16	78	90	460	1496	715	513.2		
16:48	1:18	72	89	428	1507	706	506.8		
16:50	1:20	77	91	455	1508	713	511.8		
16:53	1:22	75	90	448	1499	730	524.0		
16:54	1:24	75	90	429	1499	705	506.1		
16:57	1:26	72	91	464	1496	724	519.7		
16:59	1:28	77	89	434	1503	673	483.1		

MATR_6.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
17:01	1:30	69	88	449	1499	695	498.9		
17:03	1:32	77	89	455	1506	718	515.4		
17:05	1:34	74	89	428	1497	721	517.6		
17:07	1:36	73	90	456	1493	723	519.0		
17:09	1:38	78	90	447	1496	729	523.3		
17:11	1:40	75	90	447	1485	685	491.7		
17:13	1:42	72	88	452	1501	714	512.5		
17:15	1:44	73	89	440	1500	709	508.9		
17:17	1:46	71	90	451	1502	717	514.7		
17:19	1:48	74	89	427	1495	702	503.9		
17:21	1:50	74	90	462	1496	718	515.4		
17:23	1:52	73	90	424	1496	658	472.3		
17:25	1:54	75	89	460	1505	714	512.5		
17:27	1:56	75	89	423	1499	709	508.9		
17:29	1:58	75	90	465	1496	722	518.3		
17:31	2:00	76	90	424	1500	708	508.2		
17:33	2:02	74	89	448	1498	678	486.7	Begin Steady-state	
17:35	2:04	72	89	440	1498	672	482.4		
17:37	2:06	73	89	437	1497	690	495.3		
17:39	2:08	74	89	425	1500	679	487.4		
17:41	2:10	74	90	447	1499	697	500.3		
17:43	2:12	74	90	424	1497	654	469.5		
17:45	2:15	74	89	440	1497	679	487.4		
17:47	2:17	71	89	454	1505	683	490.3		
17:49	2:19	76	89	423	1500	693	497.5		
17:51	2:21	74	89	444	1500	700	502.5		
17:53	2:23	74	90	458	1491	700	502.5		
17:55	2:25	71	90	427	1499	656	470.9		
17:57	2:27	75	88	451	1500	669	480.2		
17:59	2:29	71	88	467	1496	688	493.9		
18:01	2:31	78	89	424	1506	699	501.8		
18:03	2:33	73	90	436	1503	692	496.7		
18:05	2:35	70	90	460	1502	697	500.3		
18:07	2:37	72	89	435	1503	644	462.3		
18:09	2:39	74	88	426	1497	678	486.7		
18:11	2:41	72	88	443	1496	680	488.1		
18:13	2:43	77	89	444	1503	687	493.1		
18:15	2:45	74	90	426	1503	680	488.1		
18:17	2:47	77	90	433	1504	635	455.8		
18:19	2:49	69	90	448	1503	662	475.2		
18:21	2:51	75	88	435	1497	669	480.2		
18:23	2:53	72	88	459	1493	676	485.3		
18:25	2:55	74	88	428	1494	685	491.7		
18:27	2:57	78	89	460	1486	678	486.7		
18:29	2:59	78	89	431	1497	688	493.9		
18:31	3:01	75	90	469	1498	698	501.0		
18:33	3:03	76	90	425	1503	692	496.7		
18:35	3:05	73	90	461	1492	664	476.6		
18:37	3:07	74	88	435	1496	686	492.4		
18:39	3:09	70	89	445	1491	689	494.6		

MATR_6.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
18:41	3:11	73	89	438	1500	692	496.7		
18:43	3:13	75	90	439	1503	691	496.0		
18:45	3:15	69	90	442	1501	639	458.7		
18:47	3:17	78	89	451	1492	688	493.9		
18:49	3:19	78	89	451	1496	684	491.0		
18:51	3:21	72	89	424	1503	695	498.9		
18:53	3:23	78	90	464	1495	688	493.9		
18:55	3:25	75	90	429	1498	694	498.2		
18:57	3:27	69	89	453	1500	669	480.2		
18:59	3:29	69	89	423	1496	689	494.6		
19:01	3:31	77	89	446	1499	673	483.1		
19:03	3:33	72	89	446	1499	679	487.4		
19:05	3:35	73	90	433	1495	701	503.2		
19:07	3:37	75	91	457	1502	656	470.9		
19:09	3:39	77	88	430	1494	661	474.5		
19:11	3:41	69	88	439	1504	675	484.5		
19:13	3:43	78	88	450	1499	675	484.5		
19:15	3:45	73	89	412	1505	681	488.8		
19:17	3:47	71	89	463	1504	677	486.0		
19:19	3:49	74	90	422	1501	670	480.9		
19:21	3:51	70	89	452	1489	688	493.9		
19:23	3:53	75	89	452	1500	678	486.7		
19:25	3:55	73	89	436	1504	694	498.2		
19:27	3:57	74	89	456	1485	679	487.4		
19:29	3:59	70	90	429	1496	657	471.6	End Steady-state	
Steady-state Avg.		74	89	441	1498	679	488		
Maximum		78	91	469	1506	701	503		
Minimum		69	88	412	1485	635	456		
Standard Deviation		2.7	0.7	13.6	4.6	15.3	11.0		
TEST CONDITIONS: MATR_6.XLS				Temp. = 90 F					
				Press. = 75 psig					
Date Run: 13-May-96				Rotor = 1500 rpm					
				Solids = 1 wt%					
				Flow = 500 L/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
20:24	0:00	64	91	443	2013	846	607.3		
20:26	0:02	58	89	442	2011	818	587.2		
20:28	0:03	61	89	444	2010	874	627.4		
20:30	0:06	63	90	452	2009	851	610.9		
20:32	0:08	63	90	444	2010	856	614.5		
20:34	0:10	59	90	438	2012	799	573.5		
20:36	0:12	63	90	449	2010	839	602.3		
20:38	0:14	60	89	450	2010	846	607.3		
20:40	0:16	66	90	443	2019	789	566.4		
20:42	0:18	65	89	442	2010	812	582.9		
20:44	0:20	58	89	446	2010	820	588.6		
20:46	0:22	65	90	441	2016	834	598.7		
20:48	0:24	65	89	458	2009	773	554.9		
20:50	0:26	57	89	439	2011	795	570.7		
20:52	0:28	62	90	445	2010	804	577.1		
20:54	0:30	60	91	452	2009	762	547.0		
20:56	0:32	57	88	442	2010	786	564.2		
20:58	0:34	59	89	445	2009	793	569.2		
21:00	0:36	57	90	450	2015	790	567.1		
21:02	0:38	63	90	450	2006	762	547.0		
21:04	0:40	67	88	439	2013	785	563.5		
21:06	0:42	59	89	439	2008	794	570.0		
21:08	0:44	65	90	449	2013	804	577.1		
21:10	0:46	66	90	433	2017	739	530.5		
21:12	0:48	65	89	450	2009	769	552.0		
21:14	0:50	60	89	450	2016	789	566.4		
21:16	0:52	58	90	443	2006	806	578.6		
21:18	0:54	58	90	455	2009	740	531.2		
21:20	0:56	61	89	452	2005	755	542.0		
21:22	0:58	61	89	432	2007	776	557.0		
21:24	1:00	56	90	454	2007	764	548.4		
21:26	1:02	63	89	446	2010	740	531.2		
21:28	1:04	59	89	453	2010	766	549.9		
21:30	1:06	67	90	446	2010	766	549.9		
21:32	1:08	64	91	446	2010	732	525.5		
21:34	1:10	57	89	446	2009	777	557.8		
21:36	1:12	63	89	448	2005	775	556.3		
21:38	1:14	63	90	446	2010	770	552.7		
21:40	1:16	65	89	448	2010	737	529.0		
21:42	1:18	63	89	446	2005	752	539.8		
21:44	1:20	64	89	451	2011	787	564.9		
21:46	1:22	66	90	441	2009	734	526.9	Begin Steady-state	
21:48	1:24	63	89	460	2007	736	528.3		
21:50	1:26	60	89	450	2008	735	527.6		
21:52	1:28	58	90	449	2009	751	539.1		

MATR_7.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
21:54	1:30	60	91	449	2009	720	516.8		
21:56	1:32	62	88	444	2010	751	539.1		
21:58	1:34	65	89	452	2007	747	536.2		
22:00	1:36	62	90	454	2003	746	535.5		
22:02	1:38	61	90	446	2004	696	499.6		
22:04	1:40	62	89	457	2010	738	529.8		
22:06	1:42	62	89	453	2006	736	528.3		
22:08	1:44	61	90	448	2003	753	540.5		
22:10	1:46	59	89	448	2010	697	500.3		
22:13	1:48	60	88	454	2007	750	538.4		
22:15	1:50	62	89	452	2009	749	537.7		
22:17	1:52	62	90	452	2003	746	535.5		
22:19	1:54	62	89	456	2006	712	511.1		
22:21	1:56	58	89	455	2012	737	529.0		
22:23	1:58	56	89	439	2009	744	534.1		
22:25	2:00	64	90	450	2012	725	520.4		
22:27	2:02	62	88	442	2011	732	525.5		
22:29	2:04	57	89	451	2006	730	524.0		
22:31	2:06	57	89	448	2006	740	531.2		
22:33	2:08	63	90	441	2007	710	509.7		
22:35	2:10	62	89	459	2007	741	531.9		
22:37	2:12	58	89	436	2004	734	526.9		
22:39	2:14	62	90	456	2007	736	528.3		
22:41	2:16	62	90	450	2006	706	506.8		
22:43	2:18	63	89	455	2005	732	525.5		
22:45	2:20	65	89	453	2005	759	544.8		
22:47	2:22	63	90	459	2010	759	544.8		
22:49	2:24	58	90	448	2006	699	501.8		
22:51	2:26	65	88	451	2011	736	528.3		
22:53	2:28	63	89	454	2007	749	537.7		
22:55	2:30	63	90	454	2014	744	534.1		
22:57	2:32	63	89	442	2008	713	511.8		
22:59	2:34	58	89	448	2012	731	524.7		
23:01	2:36	57	89	454	2008	744	534.1		
23:03	2:38	59	91	455	2012	726	521.1		
23:05	2:40	63	89	446	2006	717	514.7		
23:07	2:42	61	89	447	2019	727	521.9		
23:09	2:44	65	90	454	2015	745	534.8		
23:11	2:46	65	90	455	2007	716	514.0		
23:13	2:48	64	88	445	2006	727	521.9		
23:15	2:50	59	89	444	2005	736	528.3		
23:17	2:52	61	89	453	2005	747	536.2		
23:19	2:54	63	90	438	2013	739	530.5		
23:21	2:56	58	89	440	2009	732	525.5		
23:23	2:58	63	89	458	2006	734	526.9		
23:25	3:01	64	89	450	2007	762	547.0		
23:27	3:03	63	90	454	2010	717	514.7		
23:29	3:05	56	88	458	2008	738	529.8		
23:31	3:07	61	89	449	2009	728	522.6		
23:33	3:09	58	90	451	2008	746	535.5		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
23:35	3:11	59	90	438	2007	702	503.9		
23:37	3:13	63	88	454	2008	732	525.5		
23:39	3:15	59	89	451	2008	735	527.6		
23:41	3:17	63	90	454	2010	759	544.8		
23:43	3:19	60	90	448	2006	687	493.1		
23:45	3:21	61	88	453	1998	733	526.2		
23:47	3:23	63	89	459	2006	748	536.9		
23:49	3:25	63	90	453	2008	757	543.4		
23:51	3:27	59	90	454	2006	715	513.2		
23:53	3:29	59	89	456	2010	734	526.9		
23:55	3:31	63	89	458	2008	741	531.9	End Steady-state	
Steady-state Avg		61	89	451	2008	734	527		
Maximum		66	91	460	2019	762	547		
Minimum		56	88	436	1998	687	493		
Standard Deviation		2.5	0.7	5.8	3.2	16.7	12.0		
TEST CONDITIONS: MATR_7.XLS				Temp. =	90 F				
				Press. =	60 psig				
Date Run: 13-May-96				Rotor =	2000 rpm				
				Solids =	1 wt%				
				Flow =	500 L/hr				

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
1:06	0:00	45	90	491	1503	242	173.7		
1:08	0:01	43	89	497	1500	252	180.9		
1:10	0:03	44	89	487	1499	262	188.1		
1:12	0:05	47	90	484	1501	265	190.2		
1:14	0:07	43	90	483	1502	244	175.2		
1:16	0:09	42	89	498	1501	257	184.5		
1:18	0:12	46	89	487	1498	274	196.7		
1:20	0:14	43	91	480	1506	270	193.8		
1:23	0:16	41	90	482	1505	240	172.3		
1:25	0:18	51	89	496	1501	251	180.2		
1:27	0:20	51	89	497	1505	262	188.1		
1:29	0:22	51	89	493	1508	268	192.4		
1:31	0:24	40	90	485	1503	263	188.8		
1:33	0:26	50	90	478	1504	256	183.8	Begin Steady-state	
1:35	0:28	53	89	484	1501	250	179.5		
1:37	0:30	47	88	494	1504	258	185.2		
1:39	0:32	46	88	495	1499	252	180.9		
1:41	0:34	51	89	493	1502	264	189.5		
1:43	0:36	51	90	496	1498	263	188.8		
1:45	0:38	49	90	495	1506	249	178.7		
1:47	0:40	51	90	490	1505	262	188.1		
1:49	0:42	46	89	489	1503	259	185.9		
1:51	0:44	52	89	491	1496	267	191.7		
1:53	0:46	51	90	495	1496	267	191.7		
1:55	0:48	45	90	494	1497	242	173.7		
1:57	0:50	48	89	495	1507	252	180.9		
1:59	0:52	43	88	493	1502	255	183.0		
2:01	0:54	52	88	492	1505	257	184.5		
2:03	0:56	45	89	485	1503	255	183.0		
2:05	0:58	48	89	478	1495	266	190.9		
2:07	1:00	47	90	478	1499	270	193.8		
2:09	1:02	42	91	494	1501	249	178.7		
2:11	1:04	43	90	494	1506	242	173.7		
2:13	1:06	40	88	486	1502	254	182.3		
2:15	1:08	52	88	475	1504	260	186.6		
2:17	1:10	45	89	479	1495	257	184.5		
2:19	1:12	42	89	492	1503	253	181.6		
2:21	1:14	46	89	487	1502	261	187.4		
2:23	1:16	50	90	482	1502	269	193.1		
2:25	1:18	48	90	492	1490	248	178.0		
2:27	1:20	52	91	484	1494	247	177.3		
2:29	1:22	44	88	478	1497	255	183.0		
2:31	1:24	48	88	491	1499	252	180.9		
2:33	1:26	52	89	477	1502	264	189.5		
2:35	1:28	51	89	492	1511	258	185.2		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
2:37	1:30	46	90	484	1497	260	186.6		
2:39	1:32	47	90	482	1503	260	186.6		
2:41	1:34	50	91	477	1503	249	178.7		
2:43	1:36	40	89	477	1494	249	178.7		
2:45	1:38	49	88	491	1494	253	181.6		
2:47	1:40	52	88	478	1502	260	186.6		
2:49	1:42	48	89	491	1499	313	224.7		
2:51	1:44	44	89	477	1496	254	182.3		
2:53	1:46	48	90	485	1505	257	184.5		
2:55	1:48	48	90	487	1502	257	184.5		
2:57	1:50	40	90	476	1503	234	168.0		
2:59	1:52	50	89	490	1495	253	181.6		
3:01	1:54	42	89	475	1500	258	185.2		
3:03	1:56	42	89	491	1501	259	185.9		
3:05	1:58	42	89	480	1500	261	187.4		
3:07	2:00	42	90	474	1504	263	188.8		
3:09	2:02	45	90	493	1499	263	188.8		
3:11	2:04	49	90	473	1496	242	173.7		
3:13	2:06	50	90	492	1503	257	184.5		
3:15	2:08	44	89	482	1502	259	185.9		
3:17	2:10	41	90	481	1503	264	189.5		
3:19	2:12	42	90	483	1504	243	174.4		
3:21	2:14	45	89	478	1503	256	183.8		
3:23	2:16	43	89	489	1497	256	183.8		
3:25	2:18	42	90	475	1503	254	182.3		
3:27	2:20	43	90	482	1508	261	187.4		
3:29	2:22	50	91	488	1496	252	180.9		
3:31	2:24	43	90	473	1499	243	174.4		
3:33	2:26	44	89	489	1503	256	183.8		
3:35	2:28	46	89	485	1502	257	184.5	End Steady-state	
Steady-state Avg.		47	89	485	1501	257	184		
Maximum		53	91	496	1511	313	225		
Minimum		40	88	473	1490	234	168		
Standard Deviation		3.7	0.8	7.0	4.0	10.2	7.3		
TEST CONDITIONS: MATR_8.XLS									
				Temp. = 90°F					
Date Run: 14-May-96				Press. = 45 psig					
				Rotor = 1500 rpm					
				Solids = 30 wt%					
				Flow = 500 l/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
5:44	0:00	65	119	511	1494	391	280.7		
5:46	0:02	64	121	501	1499	331	237.6		
5:48	0:04	66	119	499	1489	320	229.7		
5:50	0:06	64	117	502	1499	354	254.1		
5:52	0:08	65	116	501	1497	363	260.6		
5:54	0:10	62	116	504	1502	364	261.3		
5:56	0:12	64	116	506	1493	383	274.9		
5:58	0:14	65	116	504	1485	386	277.1		
6:00	0:16	63	117	503	1492	373	267.8		
6:02	0:18	64	117	506	1496	385	276.4		
6:04	0:20	66	118	505	1485	393	282.1		
6:06	0:22	64	118	506	1503	382	274.2		
6:08	0:24	55	118	505	1497	371	266.3		
6:10	0:26	68	119	490	1502	418	300.1		
6:12	0:28	64	120	492	1487	369	264.9		
6:14	0:30	64	120	480	1491	295	211.8		
6:17	0:32	61	117	481	1496	351	252.0		
6:19	0:34	58	116	482	1490	356	255.5		
6:21	0:36	61	117	493	1495	370	265.6		
6:23	0:38	59	117	494	1492	369	264.9		
6:25	0:40	62	117	497	1494	380	272.8		
6:27	0:42	58	118	497	1486	376	269.9		
6:29	0:44	63	119	497	1500	374	268.5		
6:31	0:46	60	119	498	1495	385	276.4		
6:33	0:48	64	120	499	1483	382	274.2		
6:35	0:50	62	120	497	1486	372	267.0		
6:37	0:52	61	120	487	1486	362	259.9		
6:39	0:54	62	121	489	1483	384	275.6		
6:41	0:56	63	121	485	1495	314	225.4		
6:43	0:58	61	118	496	1482	371	266.3	Begin Steady-state	
6:45	1:00	62	117	495	1502	372	267.0		
6:47	1:02	64	118	497	1503	375	269.2		
6:49	1:04	63	118	497	1491	379	272.1		
6:51	1:06	62	118	497	1500	366	262.7		
6:53	1:08	65	119	499	1492	349	250.5		
6:55	1:10	63	119	499	1496	366	262.7		
6:57	1:12	59	120	499	1504	381	273.5		
6:59	1:14	65	120	487	1492	365	262.0		
7:01	1:16	64	121	487	1482	380	272.8		
7:03	1:18	57	121	488	1491	385	276.4		
7:05	1:20	58	120	492	1486	316	226.8		
7:07	1:22	56	118	495	1496	342	245.5		
7:09	1:24	61	117	493	1488	353	253.4		
7:11	1:26	64	118	494	1485	367	263.4		
7:13	1:28	62	119	494	1486	357	256.3		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
7:15	1:30	62	119	491	1494	353	253.4		
7:17	1:32	63	120	496	1480	383	274.9		
7:19	1:34	60	120	497	1489	358	257.0		
7:21	1:36	65	120	499	1503	381	273.5		
7:23	1:38	64	121	499	1494	365	262.0		
7:25	1:40	51	121	468	1481	267	191.7		
7:27	1:42	58	119	488	1490	349	250.5		
7:29	1:44	58	118	484	1490	365	262.0		
7:31	1:46	61	118	494	1491	369	264.9		
7:33	1:48	59	118	484	1493	378	271.3		
7:35	1:50	60	119	483	1503	370	265.6		
7:37	1:52	63	119	495	1489	388	278.5		
7:39	1:54	56	120	493	1497	381	273.5		
7:41	1:56	59	120	496	1494	373	267.8		
7:43	1:58	62	121	486	1493	385	276.4		
7:45	2:00	60	121	492	1494	349	250.5		
7:47	2:02	62	119	492	1485	341	244.8		
7:49	2:04	59	118	482	1489	356	255.5		
7:51	2:06	62	119	487	1489	360	258.4		
7:53	2:08	59	119	482	1485	374	268.5		
7:55	2:10	61	120	493	1496	359	257.7		
7:57	2:12	59	120	497	1484	370	265.6		
7:59	2:14	64	121	487	1495	371	266.3		
8:01	2:16	62	121	482	1489	378	271.3		
8:03	2:18	64	120	480	1489	322	231.1		
8:05	2:20	55	119	492	1495	357	256.3		
8:07	2:22	61	118	494	1497	357	256.3		
8:09	2:24	59	119	492	1493	368	264.2		
8:11	2:26	62	119	494	1493	382	274.2		
8:13	2:28	55	120	493	1489	370	265.6		
8:15	2:30	65	120	485	1482	364	261.3		
8:17	2:32	64	121	486	1483	373	267.8		
8:19	2:34	65	121	482	1496	340	244.1		
8:21	2:36	58	120	494	1484	367	263.4		
8:23	2:39	64	120	489	1489	368	264.2		
8:25	2:41	58	120	483	1485	377	270.6		
8:27	2:43	65	121	495	1483	393	282.1		
8:29	2:45	64	122	479	1482	313	224.7		
8:31	2:47	57	119	490	1496	328	235.4		
8:33	2:49	59	118	485	1496	352	252.7		
8:35	2:51	58	118	492	1504	336	241.2		
8:37	2:53	58	118	493	1484	362	259.9		
8:39	2:55	64	119	482	1497	374	268.5		
8:41	2:57	56	120	482	1482	350	251.2		
8:43	2:59	54	120	494	1489	363	260.6		
8:45	3:01	57	121	489	1496	375	269.2		
8:47	3:03	57	121	476	1489	327	234.7		
8:49	3:05	57	119	484	1489	333	239.0		
8:51	3:07	59	118	486	1484	352	252.7		
8:53	3:09	65	117	480	1491	344	246.9		

MATR_9.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
8:55	3:11	58	118	477	1501	344	246.9	End	Steady-state
Steady-state Avg.		60	119	490	1491	360	259		
Maximum		65	122	499	1504	393	282		
Minimum		51	117	468	1480	267	192		
Standard Deviation		3.2	1.2	6.7	6.3	21.1	15.2		
TEST CONDITIONS: MATR_9.XLS				Temp. = 120 F					
				Press. = 60 psig					
Date Run: 14-May-96				Rotor = 1500 rpm					
				Solids = 30 wt%					
				Flow = 500 L/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
12:22	0:00	69	120	464	1492	905	649.6		
12:24	0:02	61	121	475	1502	855	613.7		
12:26	0:04	65	122	480	1503	815	585.0		
12:28	0:06	61	120	462	1504	864	620.2		
12:30	0:08	64	120	476	1502	837	600.8		
12:32	0:10	61	121	483	1504	851	610.9		
12:34	0:12	62	118	464	1496	817	586.5		
12:36	0:14	63	118	485	1506	842	604.4		
12:38	0:16	63	118	460	1500	843	605.1		
12:40	0:18	65	119	487	1495	848	608.7		
12:42	0:20	60	120	469	1503	868	623.1		
12:44	0:22	62	121	480	1494	847	608.0		
12:46	0:24	64	121	487	1494	875	628.1		
12:48	0:26	61	120	458	1504	771	553.4		
12:50	0:28	62	117	480	1498	831	596.5		
12:52	0:30	61	118	473	1495	837	600.8		
12:54	0:32	64	119	463	1495	843	605.1		
12:56	0:34	68	120	477	1500	840	603.0		
12:58	0:36	64	120	484	1491	865	620.9		
13:00	0:38	62	122	480	1501	836	600.1		
13:02	0:40	64	119	475	1500	819	587.9		
13:04	0:42	61	118	469	1499	838	601.5	Begin Steady-state	
13:06	0:44	61	119	462	1492	862	618.8		
13:08	0:46	60	120	457	1494	849	609.4		
13:10	0:48	63	120	459	1490	830	595.8		
13:12	0:50	60	121	469	1503	852	611.6		
13:14	0:52	63	121	463	1501	779	559.2		
13:16	0:54	64	118	472	1499	835	599.4		
13:18	0:56	62	119	463	1490	852	611.6		
13:20	0:58	64	120	475	1503	860	617.3		
13:22	1:00	60	120	485	1499	839	602.3		
13:24	1:02	69	121	487	1491	889	638.1		
13:26	1:04	60	121	469	1503	842	604.4		
13:28	1:06	60	121	474	1490	774	555.6		
13:30	1:08	63	118	489	1494	831	596.5		
13:32	1:10	60	118	468	1500	833	598.0		
13:34	1:12	66	119	478	1503	847	608.0		
13:36	1:14	63	120	487	1502	852	611.6		
13:38	1:16	60	120	469	1505	856	614.5		
13:40	1:18	65	121	468	1499	875	628.1		
13:42	1:20	67	122	498	1500	892	640.3		
13:44	1:22	67	118	474	1502	837	600.8		
13:46	1:24	67	118	465	1503	850	610.2		
13:48	1:26	64	119	485	1500	859	616.6		
13:50	1:28	64	119	485	1501	871	625.2		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
13:52	1:30	63	120	465	1499	892	640.3		
13:54	1:32	63	121	496	1509	819	587.9		
13:56	1:34	57	123	479	1498	752	539.8		
13:58	1:36	64	118	481	1501	812	582.9		
14:00	1:38	62	118	497	1502	802	575.7		
14:02	1:40	62	119	478	1503	834	598.7		
14:04	1:42	63	119	493	1497	811	582.2		
14:06	1:44	64	119	483	1497	821	589.3		
14:08	1:46	59	121	496	1494	846	607.3		
14:10	1:48	62	121	485	1505	834	598.7		
14:12	1:50	63	119	491	1502	774	555.6		
14:14	1:52	66	118	479	1493	824	591.5		
14:16	1:54	58	117	491	1502	816	585.7		
14:18	1:56	62	119	472	1503	830	595.8		
14:20	1:58	62	119	493	1506	827	593.6		
14:22	2:00	57	120	489	1503	842	604.4		
14:24	2:02	62	121	496	1498	813	583.6		
14:26	2:04	61	121	481	1493	829	595.1		
14:28	2:06	66	120	481	1496	813	583.6		
14:30	2:08	62	121	504	1499	850	610.2		
14:32	2:10	66	121	478	1497	798	572.8		
14:34	2:12	58	119	474	1502	819	587.9		
14:36	2:14	58	120	487	1502	850	610.2		
14:39	2:16	65	120	494	1502	846	607.3		
14:41	2:18	62	121	484	1503	839	602.3		
14:43	2:20	59	122	496	1496	811	582.2		
14:45	2:22	62	121	481	1501	866	621.6		
14:47	2:24	62	121	499	1496	847	608.0		
14:49	2:26	57	121	490	1496	882	633.1		
14:51	2:28	65	119	480	1502	819	587.9		
14:53	2:31	65	118	503	1496	848	608.7		
14:55	2:33	62	120	478	1504	853	612.3		
14:57	2:35	55	119	487	1502	851	610.9		
14:59	2:37	66	120	490	1502	849	609.4		
15:01	2:39	65	121	494	1503	884	634.6		
15:03	2:41	60	121	480	1499	848	608.7		
15:05	2:43	57	120	489	1502	790	567.1		
15:07	2:45	64	117	499	1504	828	594.4		
15:09	2:47	65	118	480	1499	860	617.3		
15:11	2:49	55	119	482	1499	861	618.1		
15:13	2:51	58	119	504	1505	872	625.9		
15:15	2:53	59	120	480	1504	874	627.4		
15:17	2:55	62	121	486	1496	861	618.1		
15:19	2:57	56	121	505	1504	891	639.6		
15:21	2:59	63	120	492	1496	821	589.3		
15:23	3:01	62	118	474	1503	827	593.6		
15:25	3:03	58	118	486	1502	842	604.4		
15:27	3:05	58	119	508	1503	863	619.5		
15:29	3:07	60	119	492	1503	871	625.2		
15:31	3:09	55	120	480	1494	879	631.0		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
15:33	3:11	56	120	473	1503	888	637.4	End Steady-state	
Steady-state Avg.		62	120	483	1500	841	604		
Maximum		69	123	508	1509	892	640		
Minimum		55	117	457	1490	752	540		
Standard Deviation		3.2	1.3	11.8	4.2	29.0	20.8		
TEST CONDITIONS: MATR_10.XLS				Temp. = 120 F					
				Press. = 60 psig					
Date Run: 14-May-96				Rotor = 1500 rpm					
				Solids = 1 wt%					
				Flow = 500 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
14:39	0:00	60	90	429	994	127	91.2		
14:41	0:02	56	89	426	994	117	84.0		
14:43	0:04	62	88	436	997	126	90.4		
14:45	0:06	51	89	427	996	125	89.7		
14:47	0:08	53	90	430	996	123	88.3		
14:49	0:10	53	90	434	996	116	83.3		
14:51	0:12	63	88	438	992	120	86.1		
14:53	0:14	55	89	425	996	140	100.5		
14:55	0:16	59	89	430	991	129	92.6		
14:57	0:18	60	90	433	992	124	89.0	Begin Steady-state	
14:59	0:20	57	89	432	994	126	90.4		
15:01	0:22	53	88	433	995	137	98.3		
15:03	0:24	55	89	439	998	132	94.8		
15:05	0:26	61	90	438	995	135	96.9		
15:07	0:28	54	90	417	996	122	87.6		
15:09	0:30	53	89	422	993	127	91.2		
15:11	0:32	61	88	424	992	132	94.8		
15:13	0:34	53	89	424	994	153	109.8		
15:15	0:36	60	90	422	992	132	94.8		
15:17	0:38	62	91	420	992	105	75.4		
15:19	0:40	55	88	416	994	124	89.0		
15:21	0:42	58	88	416	994	136	97.6		
15:23	0:44	65	89	417	993	151	108.4		
15:25	0:46	53	90	418	994	133	95.5		
15:27	0:48	61	90	418	995	114	81.8		
15:29	0:50	57	88	423	994	154	110.5		
15:31	0:52	61	88	432	991	123	88.3		
15:33	0:54	61	89	432	995	137	98.3		
15:35	0:56	54	90	424	996	132	94.8		
15:37	0:58	54	90	432	994	111	79.7		
15:39	1:00	57	88	426	993	122	87.6		
15:41	1:02	62	88	431	991	132	94.8		
15:43	1:04	61	89	434	992	127	91.2		
15:45	1:06	53	90	420	996	141	101.2		
15:47	1:08	54	90	419	992	124	89.0		
15:49	1:10	52	88	422	996	138	99.1		
15:51	1:12	53	88	434	991	125	89.7		
15:53	1:14	63	89	435	994	123	88.3		
15:55	1:16	62	90	417	995	133	95.5		
15:57	1:18	61	90	426	994	105	75.4		
15:59	1:20	59	88	417	993	143	102.6		
16:01	1:22	62	88	436	990	128	91.9		
16:03	1:24	53	89	420	993	150	107.7		
16:05	1:26	62	90	429	993	120	86.1		
16:07	1:28	53	89	432	993	126	90.4		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
16:09	1:30	60	88	415	997	150	107.7		
16:11	1:32	61	89	433	994	130	93.3		
16:13	1:34	64	90	426	994	129	92.6		
16:15	1:36	65	90	434	992	98	70.3		
16:17	1:38	63	88	417	991	122	87.6		
16:19	1:40	63	88	413	992	132	94.8		
16:21	1:42	55	89	421	995	124	89.0		
16:23	1:44	55	90	426	994	126	90.4		
16:25	1:46	53	90	414	991	105	75.4		
16:27	1:48	60	88	431	994	122	87.6		
16:29	1:50	54	88	416	994	123	88.3		
16:31	1:52	53	90	426	996	137	98.3		
16:33	1:54	64	90	425	992	127	91.2		
16:35	1:56	61	89	418	990	120	86.1		
16:37	1:58	62	88	431	991	123	88.3		
16:39	2:00	62	89	429	1004	180	129.2		
16:41	2:02	63	90	415	991	125	89.7		
16:44	2:04	57	90	430	994	106	76.1		
16:46	2:06	61	88	419	991	136	97.6		
16:48	2:08	54	88	421	992	122	87.6		
16:50	2:10	58	89	424	991	123	88.3		
16:52	2:12	61	90	431	994	136	97.6		
16:54	2:14	53	90	414	997	111	79.7		
16:56	2:16	57	88	415	992	111	79.7		
16:58	2:18	62	89	415	994	120	86.1		
17:00	2:20	52	90	427	994	131	94.0		
17:02	2:22	53	90	413	991	143	102.6		
17:04	2:25	64	90	415	990	110	79.0		
17:06	2:27	64	88	415	991	115	82.6		
17:08	2:29	57	88	413	990	118	84.7		
17:10	2:31	59	89	426	997	122	87.6		
17:12	2:33	55	90	433	990	83	59.6		
17:14	2:35	62	90	429	990	115	82.6		
17:16	2:37	64	89	426	990	133	95.5		
17:18	2:39	60	88	426	990	118	84.7		
17:20	2:41	62	90	421	992	122	87.6		
17:22	2:43	62	90	411	991	113	81.1		
17:24	2:45	62	89	410	996	115	82.6		
17:26	2:47	53	88	419	992	111	79.7		
17:28	2:49	54	88	429	992	134	96.2		
17:30	2:51	59	90	410	992	124	89.0		
17:32	2:53	53	91	409	991	111	79.7		
17:34	2:55	53	90	431	990	112	80.4		
17:36	2:57	59	88	416	990	117	84.0		
17:38	2:59	53	89	413	992	120	86.1		
17:40	3:01	59	90	430	993	132	94.8		
17:42	3:03	54	90	412	990	115	82.6		
17:44	3:05	57	89	430	993	120	86.1		
17:46	3:07	53	89	412	997	113	81.1		
17:48	3:09	54	89	415	993	132	94.8	End Steady-state	

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
Steady-state Avg.		58	89	423	993	126	90		
Maximum		65	91	439	1004	180	129		
Minimum		52	88	409	990	83	60		
Standard Deviation		4.0	0.9	7.8	2.4	13.7	9.8		
TEST CONDITIONS: MATR_11.XLS				Temp. =	90 F				
				Press. =	60 psig				
Date Run: 15-May-96				Rotor =	1000 rpm				
				Solids =	30 wt%				
				Flow =	420 L/hr				

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
18:33	0:00	70	89	372	1494	221	158.6		
18:35	0:02	70	91	368	1488	208	149.3		
18:37	0:04	76	90	372	1489	190	136.4		
18:39	0:06	70	88	372	1488	203	145.7		
18:41	0:08	79	89	373	1489	219	157.2		
18:43	0:10	71	90	371	1489	205	147.2		
18:45	0:12	80	91	372	1489	181	129.9		
18:47	0:14	71	89	368	1489	198	142.1		
18:49	0:16	79	89	373	1489	199	142.8		
18:51	0:18	70	90	369	1491	207	148.6		
18:53	0:20	81	91	371	1489	196	140.7		
18:55	0:22	69	89	369	1490	179	128.5		
18:57	0:24	85	88	373	1497	194	139.3		
18:59	0:26	72	89	368	1487	220	157.9		
19:02	0:28	72	91	367	1489	201	144.3		
19:04	0:30	77	89	364	1489	192	137.8		
19:06	0:32	70	88	369	1488	228	163.7		
19:08	0:34	78	89	368	1491	234	168.0		
19:10	0:36	82	91	364	1488	200	143.6		
19:12	0:38	73	90	366	1489	184	132.1		
19:14	0:40	74	89	366	1490	192	137.8		
19:16	0:42	70	89	368	1489	229	164.4		
19:18	0:44	74	90	367	1489	200	143.6		
19:20	0:46	83	91	365	1489	188	135.0		
19:22	0:48	81	89	368	1490	208	149.3		
19:24	0:50	71	88	366	1487	223	160.1		
19:26	0:52	80	89	369	1494	234	168.0		
19:28	0:54	73	91	365	1486	213	152.9		
19:30	0:56	73	89	364	1488	178	127.8		
19:32	0:58	71	88	367	1489	224	160.8		
19:34	1:00	84	90	368	1488	230	165.1		
19:36	1:02	72	90	363	1491	216	155.1	Begin Steady-state	
19:38	1:04	72	89	366	1492	198	142.1		
19:40	1:06	74	89	367	1489	226	162.2		
19:42	1:08	71	90	365	1489	241	173.0		
19:44	1:10	72	91	364	1490	205	147.2		
19:46	1:12	71	90	368	1492	210	150.7		
19:48	1:14	78	89	368	1490	216	155.1		
19:50	1:16	77	90	367	1488	230	165.1		
19:52	1:18	80	91	365	1490	190	136.4		
19:54	1:20	81	89	366	1488	197	141.4		
19:56	1:22	73	89	365	1489	220	157.9		
19:58	1:24	82	90	369	1488	234	168.0		
20:00	1:26	82	91	364	1490	200	143.6		
20:02	1:28	78	89	365	1490	190	136.4		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
20:04	1:30	79	89	364	1489	204	146.4		
20:06	1:32	73	89	364	1490	246	176.6		
20:08	1:34	81	91	362	1487	192	137.8		
20:10	1:36	82	90	363	1489	180	129.2		
20:12	1:38	81	88	363	1486	230	165.1		
20:14	1:40	77	89	365	1489	240	172.3		
20:16	1:42	85	90	365	1488	210	150.7		
20:18	1:44	82	91	363	1496	203	145.7		
20:20	1:46	72	89	364	1488	195	140.0		
20:22	1:48	78	88	364	1493	236	169.4		
20:24	1:50	80	89	363	1488	231	165.8		
20:26	1:52	79	91	362	1489	209	150.0		
20:28	1:54	85	90	360	1490	191	137.1		
20:30	1:56	76	89	362	1489	220	157.9		
20:32	1:58	75	89	364	1487	222	159.4		
20:34	2:00	83	90	362	1490	214	153.6		
20:36	2:02	79	90	360	1490	227	162.9		
20:38	2:04	80	89	362	1488	214	153.6		
20:40	2:06	76	89	361	1492	228	163.7		
20:42	2:08	75	90	363	1489	234	168.0		
20:44	2:10	81	91	361	1493	210	150.7		
20:46	2:12	81	89	361	1492	207	148.6		
20:48	2:14	75	88	363	1487	220	157.9		
20:50	2:16	73	89	363	1491	253	181.6		
20:52	2:18	73	90	362	1496	208	149.3		
20:54	2:20	75	90	360	1491	189	135.7		
20:56	2:22	72	88	363	1490	236	169.4		
20:58	2:24	75	89	363	1492	228	163.7		
21:00	2:26	80	90	359	1492	234	168.0		
21:02	2:29	73	90	360	1491	191	137.1		
21:04	2:31	76	88	363	1489	235	168.7		
21:06	2:33	75	89	362	1487	226	162.2		
21:08	2:35	75	90	361	1489	242	173.7		
21:10	2:37	80	90	360	1489	193	138.5		
21:12	2:39	80	88	364	1490	234	168.0		
21:14	2:41	80	89	360	1490	226	162.2		
21:16	2:43	80	90	360	1489	203	145.7		
21:18	2:45	84	91	361	1489	210	150.7		
21:20	2:47	84	90	362	1488	200	143.6		
21:23	2:49	73	88	364	1493	221	158.6		
21:25	2:51	75	89	361	1489	238	170.8		
21:27	2:53	75	90	363	1489	217	155.8		
21:29	2:55	82	90	362	1489	200	143.6		
21:31	2:57	78	89	364	1487	213	152.9		
21:33	2:59	72	88	364	1492	222	159.4		
21:35	3:01	75	90	364	1489	242	173.7		
21:37	3:03	78	91	360	1490	197	141.4	End Steady-state	

MATR_12.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
Steady-state Avg.		77	90	363	1490	216	155		
Maximum		85	91	369	1496	253	182		
Minimum		71	88	359	1486	180	129		
Standard Deviation		3.9	0.9	2.2	2.0	17.4	12.5		
TEST CONDITIONS: MATR_12.XLS				Temp. =	90 F				
				Press. =	75 psig				
Date Run: 15-May-96				Rotor =	1500 rpm				
				Solids =	30 wt%				
				Flow =	400 L/hr				

5/16/96

MATR_13.XLS

SpinTek II High Shear Rotary Membrane System

StreamScan™										
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX			
23:15	0:00	61	89	398	1507	281	201.7			
23:17	0:02	63	90	419	1503	263	188.8			
23:19	0:04	59	90	417	1509	315	226.1			
23:21	0:06	64	91	404	1510	241	173.0			
23:23	0:08	66	90	417	1499	299	214.6			
23:25	0:10	63	89	421	1508	274	196.7			
23:27	0:12	58	91	419	1503	221	158.6			
23:29	0:14	65	90	399	1497	323	231.9			
23:31	0:16	57	89	426	1503	252	180.9			
23:33	0:18	62	91	424	1505	301	216.1			
23:35	0:20	63	90	443	1507	316	226.8			
23:37	0:22	61	90	414	1502	321	230.4			
23:39	0:24	64	90	427	1498	296	212.5			
23:41	0:26	64	89	411	1506	308	221.1			
23:43	0:28	58	89	411	1501	273	196.0			
23:45	0:30	63	91	421	1507	270	193.8			
23:47	0:32	57	90	422	1497	332	238.3			
23:49	0:34	62	89	406	1507	359	257.7			
23:51	0:36	63	91	407	1497	342	245.5			
23:53	0:38	58	90	427	1509	293	210.3			
23:55	0:40	61	89	421	1509	277	198.8			
23:58	0:42	60	90	418	1509	307	220.4			
0:00	0:44	58	90	407	1499	264	189.5			
0:02	0:46	57	89	436	1501	252	180.9			
0:04	0:48	63	90	409	1503	334	239.8			
0:06	0:50	62	91	409	1498	324	232.6			
0:08	0:52	64	90	420	1507	317	227.6			
0:10	0:54	60	89	408	1518	298	213.9			
0:12	0:56	57	91	411	1502	268	192.4			
0:14	0:58	57	91	399	1507	236	169.4			
0:16	1:00	63	89	411	1503	284	203.9			
0:18	1:02	59	90	423	1499	332	238.3			
0:20	1:04	66	91	405	1500	255	183.0			
0:22	1:06	59	89	404	1503	301	216.1			
0:24	1:08	66	89	417	1493	332	238.3			
0:26	1:10	64	90	412	1502	326	234.0			
0:28	1:12	62	90	411	1502	294	211.0			
0:30	1:14	61	89	426	1496	320	229.7			
0:32	1:16	65	90	419	1502	305	218.9			
0:34	1:18	58	91	401	1499	262	188.1			
0:36	1:20	62	89	414	1509	306	219.7			
0:38	1:22	61	90	437	1502	331	237.6			
0:40	1:24	66	90	409	1510	344	246.9			
0:42	1:26	61	89	407	1503	294	211.0			
0:44	1:28	61	90	407	1503	313	224.7			

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
0:46	1:30	63	91	412	1508	243	174.4		
0:48	1:32	62	89	414	1507	308	221.1		
0:50	1:34	59	89	426	1506	294	211.0		
0:52	1:36	66	90	418	1502	289	207.5		
0:54	1:38	63	89	402	1504	244	175.2		
0:56	1:40	61	90	426	1504	297	213.2		
0:58	1:42	59	91	412	1501	327	234.7		
1:00	1:44	59	90	429	1506	227	162.9		
1:02	1:46	62	90	407	1502	254	182.3		
1:04	1:48	59	90	406	1506	329	236.2		
1:06	1:50	57	91	403	1496	230	165.1		
1:08	1:52	57	89	413	1508	284	203.9		
1:10	1:54	58	89	420	1498	341	244.8		
1:12	1:56	67	90	415	1500	288	206.7		
1:14	1:58	58	89	406	1500	276	198.1		
1:16	2:00	63	90	417	1509	294	211.0	Begin Steady-state	
1:18	2:02	58	91	409	1501	292	209.6		
1:20	2:04	57	90	419	1510	289	207.5		
1:22	2:06	59	90	411	1503	302	216.8		
1:24	2:08	60	90	397	1501	332	238.3		
1:26	2:10	60	91	408	1503	287	206.0		
1:28	2:12	68	89	420	1506	308	221.1		
1:30	2:14	62	90	419	1504	328	235.4		
1:32	2:16	61	90	411	1510	279	200.3		
1:34	2:18	58	89	418	1501	313	224.7		
1:36	2:20	63	90	406	1513	322	231.1		
1:38	2:22	67	91	400	1501	287	206.0		
1:40	2:24	65	89	415	1503	291	208.9		
1:42	2:26	58	89	416	1500	309	221.8		
1:44	2:28	67	90	409	1508	325	233.3		
1:46	2:30	66	90	412	1502	276	198.1		
1:48	2:32	60	89	416	1506	309	221.8		
1:50	2:34	60	90	416	1499	312	224.0		
1:52	2:36	58	91	413	1497	293	210.3		
1:54	2:39	58	90	402	1506	294	211.0		
1:56	2:41	58	89	418	1501	297	213.2		
1:58	2:43	62	90	417	1500	326	234.0		
2:00	2:45	65	91	411	1503	289	207.5		
2:02	2:47	59	89	409	1508	300	215.3		
2:04	2:49	60	90	412	1493	329	236.2		
2:06	2:51	64	90	424	1505	277	198.8		
2:08	2:53	59	89	410	1507	306	219.7		
2:10	2:55	61	89	410	1509	296	212.5		
2:12	2:57	58	91	407	1503	310	222.5		
2:14	2:59	67	90	404	1497	300	215.3		
2:16	3:01	56	89	404	1493	299	214.6		
2:18	3:03	58	90	421	1510	309	221.8		
2:20	3:05	67	91	413	1505	300	215.3		
2:22	3:07	68	89	403	1502	320	229.7		
2:24	3:09	60	89	417	1500	300	215.3		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
2:26	3:11	56	90	409	1507	305	218.9		
2:28	3:13	63	90	399	1495	301	216.1		
2:30	3:15	60	89	407	1506	313	224.7		
2:32	3:17	60	90	412	1502	331	237.6		
2:34	3:19	63	91	404	1506	281	201.7		
2:36	3:21	66	88	405	1498	295	211.8		
2:38	3:23	67	89	412	1505	321	230.4		
2:40	3:25	60	90	425	1503	306	219.7		
2:42	3:27	63	90	392	1504	297	213.2		
2:44	3:29	56	89	420	1503	310	222.5		
2:46	3:31	59	90	418	1506	315	226.1		
2:48	3:33	59	90	400	1502	298	213.9		
2:51	3:35	60	89	418	1508	309	221.8		
2:53	3:37	59	90	407	1508	301	216.1		
2:55	3:39	59	90	408	1508	294	211.0		
2:57	3:41	60	89	422	1508	291	208.9		
2:59	3:43	58	89	418	1500	319	229.0		
3:01	3:45	68	90	406	1503	330	236.9		
3:03	3:47	59	90	406	1498	282	202.4		
3:05	3:49	67	89	418	1494	328	235.4		
3:07	3:51	64	90	419	1505	333	239.0		
3:09	3:53	61	91	421	1502	288	206.7		
3:11	3:55	56	88	406	1505	302	216.8	End Steady-state	
Steady-state Avg.		61	90	411	1503	304	218		
Maximum		68	91	425	1513	333	239		
Minimum		56	88	392	1493	276	198		
Standard Deviation		3.6	0.8	7.2	4.4	15.2	10.9		
TEST CONDITIONS: MATR_13.XLS				Temp. = 90°F					
				Press. = 60 psig					
Date Run: 16-May-96				Rotor = 1500 rpm					
				Solids = 15 wt%					
				Flow = 400 L/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™									
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
4:55	0:00	62	117	451	999	308	221.1		
4:57	0:02	61	118	460	999	330	236.9		
4:59	0:04	59	118	465	997	330	236.9		
5:01	0:06	60	119	467	1000	338	242.6		
5:03	0:08	60	119	456	999	321	230.4		
5:05	0:10	67	119	470	1002	322	231.1		
5:07	0:12	59	119	472	1004	321	230.4		
5:09	0:14	59	120	475	997	304	218.2		
5:11	0:16	59	120	465	998	330	236.9		
5:13	0:18	61	119	465	997	303	217.5		
5:15	0:20	61	117	479	999	310	222.5		
5:17	0:22	65	117	470	997	318	228.3		
5:19	0:24	64	117	453	999	305	218.9		
5:21	0:26	62	118	462	1001	325	233.3		
5:23	0:28	65	118	490	997	310	222.5		
5:25	0:30	63	119	470	997	319	229.0		
5:27	0:32	58	119	455	998	290	208.2		
5:29	0:34	58	119	477	999	311	223.2		
5:32	0:36	62	119	474	1003	315	226.1		
5:34	0:38	58	120	466	1001	317	227.6		
5:36	0:40	60	120	469	996	322	231.1		
5:38	0:42	62	120	449	997	279	200.3		
5:40	0:44	57	118	463	998	298	213.9		
5:42	0:46	59	117	473	1000	313	224.7		
5:44	0:48	63	118	465	1001	296	212.5		
5:46	0:50	56	118	481	997	312	224.0		
5:48	0:52	64	118	459	997	323	231.9		
5:50	0:54	57	119	464	1000	317	227.6		
5:52	0:56	57	119	477	998	307	220.4		
5:54	0:58	61	119	473	997	328	235.4		
5:56	1:00	61	119	480	997	328	235.4		
5:58	1:02	58	120	473	998	315	226.1		
6:00	1:04	58	120	485	997	315	226.1		
6:02	1:06	63	120	480	1000	304	218.2		
6:04	1:08	66	120	485	997	340	244.1		
6:06	1:10	58	121	472	1000	307	220.4		
6:08	1:12	58	121	459	999	320	229.7		
6:10	1:14	61	119	470	997	303	217.5	Begin Steady-state	
6:12	1:16	60	118	470	998	309	221.8		
6:14	1:18	59	118	473	1000	295	211.8		
6:16	1:20	57	118	476	998	297	213.2		
6:18	1:22	56	118	466	1000	302	216.8		
6:20	1:24	58	119	480	997	298	213.9		
6:22	1:26	57	119	478	998	309	221.8		
6:24	1:28	58	119	470	997	316	226.8		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
6:26	1:30	58	119	468	998	295	211.8		
6:28	1:32	58	120	445	1001	312	224.0		
6:30	1:34	60	120	464	999	316	226.8		
6:32	1:36	61	120	489	999	309	221.8		
6:34	1:38	58	121	477	1000	318	228.3		
6:36	1:40	61	121	483	997	327	234.7		
6:38	1:42	57	121	456	997	315	226.1		
6:40	1:44	58	120	472	995	292	209.6		
6:42	1:46	58	118	471	997	305	218.9		
6:44	1:48	64	118	460	998	311	223.2		
6:46	1:50	56	119	470	999	305	218.9		
6:48	1:52	60	119	470	1000	310	222.5		
6:50	1:54	63	119	480	997	316	226.8		
6:52	1:56	63	119	471	1001	306	219.7		
6:54	1:58	59	120	455	997	314	225.4		
6:56	2:00	62	120	456	998	311	223.2		
6:58	2:02	63	120	492	997	302	216.8		
7:00	2:05	58	120	462	997	299	214.6		
7:02	2:07	62	121	463	998	316	226.8		
7:04	2:09	56	121	467	998	325	233.3		
7:06	2:11	62	121	473	1000	301	216.1		
7:08	2:13	56	119	467	999	316	226.8		
7:10	2:15	62	119	471	997	323	231.9		
7:12	2:17	56	119	478	998	314	225.4		
7:14	2:19	61	119	479	997	352	252.7		
7:16	2:21	59	120	451	998	300	215.3		
7:18	2:23	61	120	472	998	325	233.3		
7:20	2:25	57	120	472	997	300	215.3		
7:22	2:27	58	121	460	995	315	226.1		
7:24	2:29	56	120	473	996	303	217.5		
7:26	2:31	61	121	481	996	307	220.4		
7:28	2:33	56	120	470	997	258	185.2		
7:30	2:35	60	120	465	997	290	208.2		
7:32	2:37	56	120	465	999	317	227.6		
7:34	2:39	56	120	464	997	314	225.4		
7:36	2:41	61	120	479	997	312	224.0		
7:38	2:43	56	121	499	1002	301	216.1		
7:40	2:45	56	120	452	1000	307	220.4		
7:42	2:47	57	119	475	998	302	216.8		
7:44	2:49	57	119	471	999	312	224.0		
7:46	2:51	58	120	471	996	303	217.5		
7:48	2:53	64	120	458	997	299	214.6		
7:50	2:55	56	120	471	997	315	226.1		
7:52	2:57	64	120	463	997	312	224.0		
7:54	2:59	56	121	481	999	266	190.9		
7:56	3:01	65	121	467	999	314	225.4		
7:58	3:03	57	121	464	995	329	236.2		
8:01	3:05	61	121	463	997	299	214.6		
8:03	3:07	56	120	472	1000	270	193.8		
8:05	3:09	63	118	473	997	315	226.1		

MATR_14.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
8:07	3:11	56	118	478	999	304	218.2		
8:09	3:13	56	119	487	998	323	231.9	End Steady-state	
Steady-state Avg.		59	120	470	998	308	221		
Maximum		65	121	499	1002	352	253		
Minimum		56	118	445	995	258	185		
Standard Deviation		2.7	1.0	9.9	1.5	14.4	10.3		
TEST CONDITIONS: MATR_14.XLS				Temp. = 120°F					
				Press. = 60 psig					
Date Run: 16-May-96				Rotor = 1000 rpm					
				Solids = 15 wt%					
				Flow = 500 L/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
9:53	0:00	59	61	409	1508	142	101.9		
9:55	0:02	57	61	409	1503	142	101.9		
9:57	0:04	60	61	408	1505	142	101.9		
9:59	0:06	53	61	408	1505	140	100.5		
10:01	0:08	59	61	407	1514	140	100.5		
10:03	0:10	54	61	407	1493	138	99.1		
10:05	0:12	62	60	407	1503	140	100.5		
10:07	0:14	57	61	406	1511	125	89.7		
10:09	0:16	52	60	406	1503	135	96.9		
10:11	0:18	67	60	375	1503	164	117.7		
10:13	0:20	62	61	378	1501	181	129.9		
10:15	0:22	57	60	405	1501	143	102.6		
10:17	0:24	58	61	404	1506	141	101.2		
10:19	0:26	61	61	405	1504	134	96.2		
10:21	0:28	54	61	404	1496	139	99.8		
10:23	0:30	52	60	404	1504	146	104.8		
10:25	0:32	52	60	403	1504	146	104.8		
10:27	0:34	63	61	403	1506	142	101.9		
10:29	0:36	52	60	402	1498	134	96.2		
10:31	0:38	53	60	403	1507	144	103.4		
10:34	0:40	59	61	402	1500	141	101.2		
10:36	0:42	53	60	402	1506	140	100.5		
10:38	0:44	53	60	402	1501	123	88.3		
10:40	0:46	54	60	402	1503	166	119.2		
10:42	0:48	62	61	400	1496	143	102.6		
10:44	0:50	57	61	402	1501	145	104.1		
10:46	0:52	52	60	400	1510	142	101.9		
10:48	0:54	52	61	402	1505	152	109.1		
10:50	0:56	52	61	400	1506	142	101.9		
10:52	0:58	52	61	402	1503	140	100.5		
10:54	1:00	54	61	400	1504	176	126.3		
10:56	1:02	58	61	402	1494	126	90.4		
10:58	1:04	57	61	401	1509	153	109.8		
11:00	1:06	54	61	401	1518	142	101.9		
11:02	1:08	55	60	400	1504	141	101.2		
11:04	1:10	52	61	400	1503	144	103.4		
11:06	1:12	69	61	366	1499	164	117.7		
11:08	1:14	65	61	368	1506	105	75.4		
11:10	1:16	68	61	366	1507	168	120.6		
11:12	1:18	67	61	365	1501	156	112.0		
11:14	1:20	62	61	366	1509	144	103.4		
11:16	1:22	53	61	387	1503	143	102.6		
11:18	1:24	61	61	387	1507	139	99.8		
11:20	1:26	59	61	388	1512	147	105.5		
11:22	1:28	57	61	387	1507	143	102.6		

MATR_15.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
11:24	1:30	64	61	387	1503	142	101.9		
11:26	1:32	54	61	386	1494	142	101.9		
11:28	1:34	55	61	387	1505	154	110.5		
11:30	1:36	57	60	387	1496	142	101.9		
11:32	1:38	64	61	386	1506	147	105.5		
11:34	1:40	57	61	386	1494	152	109.1		
11:36	1:42	56	61	387	1503	140	100.5		
11:38	1:44	55	61	387	1504	146	104.8		
11:40	1:46	64	61	385	1497	147	105.5		
11:42	1:48	52	61	385	1509	132	94.8		
11:44	1:50	56	61	387	1495	142	101.9		
11:46	1:52	55	61	385	1498	136	97.6		
11:48	1:54	52	61	386	1496	182	130.6	Begin Steady-state	
11:50	1:56	54	61	385	1504	137	98.3		
11:52	1:58	53	61	383	1498	154	110.5		
11:54	2:00	58	61	384	1502	135	96.9		
11:56	2:02	53	61	385	1496	146	104.8		
11:58	2:04	60	61	385	1503	143	102.6		
12:00	2:06	55	61	385	1500	161	115.6		
12:02	2:08	56	61	383	1509	146	104.8		
12:04	2:10	58	61	385	1504	167	119.9		
12:06	2:12	56	61	383	1503	143	102.6		
12:08	2:14	52	61	383	1506	163	117.0		
12:10	2:17	52	61	384	1496	161	115.6		
12:12	2:18	56	61	383	1498	143	102.6		
12:14	2:21	68	61	304	1503	200	143.6		
12:16	2:23	57	61	352	1501	176	126.3		
12:18	2:25	62	61	352	1503	131	94.0		
12:20	2:27	58	61	352	1498	178	127.8		
12:22	2:29	60	61	351	1498	171	122.7		
12:24	2:31	57	61	349	1497	152	109.1		
12:26	2:33	63	61	350	1501	188	135.0		
12:28	2:35	57	61	351	1503	178	127.8		
12:30	2:37	59	62	349	1500	164	117.7		
12:32	2:39	64	62	349	1498	161	115.6		
12:34	2:41	56	62	350	1496	175	125.6		
12:36	2:43	56	62	351	1501	162	116.3		
12:38	2:45	56	62	349	1502	168	120.6		
12:40	2:47	62	61	351	1500	157	112.7		
12:43	2:49	57	62	349	1501	168	120.6		
12:45	2:51	67	62	350	1499	162	116.3		
12:47	2:53	56	62	350	1502	128	91.9		
12:49	2:55	64	62	351	1503	164	117.7		
12:51	2:57	57	61	349	1502	155	111.3		
12:53	2:59	61	62	348	1498	156	112.0		
12:55	3:01	59	62	349	1496	170	122.0		
12:57	3:03	55	61	349	1503	159	114.1		
12:59	3:05	61	61	349	1498	165	118.4		
13:01	3:07	67	62	349	1489	173	124.2		
13:03	3:09	66	61	349	1496	156	112.0		

MATR_15.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
13:05	3:11	63	61	350	1494	137	98.3		
13:07	3:13	65	62	350	1494	166	119.2		
13:09	3:15	62	62	348	1502	141	101.2		
13:11	3:17	68	62	348	1491	149	107.0		
13:13	3:19	60	62	349	1499	183	131.4		
13:15	3:21	64	61	349	1500	151	108.4		
13:17	3:23	62	62	347	1499	163	117.0		
13:19	3:25	59	62	349	1504	144	103.4		
13:21	3:27	68	61	349	1503	159	114.1		
13:23	3:29	57	62	347	1496	168	120.6		
13:25	3:31	58	61	348	1493	145	104.1		
13:27	3:33	64	61	349	1496	151	108.4		
13:29	3:35	55	60	347	1495	144	103.4		
13:31	3:37	56	61	347	1495	176	126.3		
13:33	3:39	56	60	347	1503	162	116.3		
13:35	3:41	62	60	350	1491	144	103.4		
13:37	3:43	65	61	348	1501	152	109.1		
13:39	3:45	57	61	347	1495	155	111.3		
13:41	3:47	59	61	349	1494	156	112.0		
13:43	3:49	68	60	350	1501	156	112.0		
13:45	3:51	58	61	348	1496	154	110.5		
13:47	3:53	62	60	348	1502	130	93.3		
13:49	3:55	55	61	348	1497	154	110.5		
13:51	3:57	54	60	346	1497	116	83.3		
13:53	3:59	55	61	348	1491	182	130.6		
13:55	4:01	63	60	347	1504	186	133.5	End Steady-state	
Steady-state Avg.		59	61	355	1499	158	114		
Maximum		68	62	386	1509	200	144		
Minimum		52	60	304	1489	116	83		
Standard Deviation		4.4	0.6	15.7	4.0	16.0	11.5		
TEST CONDITIONS: MATR_15.XLS				Temp. = 60°F					
				Press. = 60 psig					
Date Run: 16-May-96				Rotor = 1500 rpm					
				Solids = 30 wt%					
				Flow = 400 L/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
15:15	0:00	59	90	359	1511	269	193.1		
15:17	0:02	65	89	368	1516	289	207.5		
15:19	0:04	66	89	377	1517	304	218.2		
15:21	0:06	65	90	363	1518	313	224.7		
15:23	0:08	61	90	368	1515	275	197.4		
15:25	0:10	60	89	358	1516	314	225.4		
15:27	0:12	65	90	373	1517	313	224.7		
15:29	0:14	60	90	363	1513	281	201.7		
15:31	0:16	59	89	358	1503	297	213.2		
15:33	0:18	65	89	374	1510	312	224.0		
15:35	0:20	66	90	361	1507	301	216.1		
15:37	0:22	69	90	359	1505	277	198.8		
15:39	0:24	65	88	365	1505	302	216.8		
15:41	0:26	63	90	370	1516	292	209.6		
15:43	0:28	70	90	360	1512	297	213.2		
15:45	0:30	59	91	369	1511	302	216.8		
15:47	0:32	65	91	368	1512	269	193.1		
15:49	0:34	58	89	366	1511	285	204.6		
15:51	0:36	58	89	374	1507	294	211.0		
15:53	0:38	64	90	370	1516	304	218.2		
15:55	0:40	62	90	358	1508	274	196.7		
15:57	0:42	63	89	377	1514	300	215.3		
15:59	0:44	63	89	366	1517	310	222.5		
16:01	0:46	59	91	359	1513	315	226.1		
16:03	0:48	60	90	367	1510	290	208.2		
16:05	0:50	61	89	386	1517	301	216.1		
16:07	0:52	64	90	370	1519	338	242.6		
16:09	0:54	63	90	374	1522	285	204.6		
16:11	0:56	67	89	389	1515	293	210.3		
16:14	0:58	63	90	378	1517	328	235.4		
16:16	1:00	64	91	374	1510	298	213.9		
16:18	1:02	60	90	363	1513	282	202.4		
16:20	1:04	61	89	373	1508	323	231.9		
16:22	1:06	57	90	391	1510	297	213.2	Begin Steady-state	
16:24	1:08	61	91	391	1520	269	193.1		
16:26	1:10	59	89	400	1512	279	200.3		
16:28	1:12	55	89	374	1514	307	220.4		
16:30	1:14	59	90	397	1513	301	216.1		
16:32	1:16	62	90	388	1500	269	193.1		
16:34	1:18	55	89	394	1503	303	217.5		
16:36	1:20	56	90	402	1513	297	213.2		
16:38	1:22	61	90	374	1515	264	189.5		
16:40	1:24	59	89	392	1514	296	212.5		
16:42	1:26	65	90	400	1513	302	216.8		
16:44	1:28	55	90	396	1512	277	198.8		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
16:46	1:30	59	89	400	1514	309	221.8		
16:48	1:32	63	89	397	1517	294	211.0		
16:50	1:34	55	91	389	1503	278	199.6		
16:52	1:36	57	89	382	1504	294	211.0		
16:54	1:38	56	89	393	1502	304	218.2		
16:56	1:40	64	91	382	1518	278	199.6		
16:58	1:42	60	90	386	1515	288	206.7		
17:00	1:44	63	90	395	1514	298	213.9		
17:02	1:46	63	91	384	1515	282	202.4		
17:04	1:48	64	90	400	1507	293	210.3		
17:06	1:50	60	89	391	1523	305	218.9		
17:08	1:52	55	91	399	1515	296	212.5		
17:10	1:54	57	90	394	1512	273	196.0		
17:12	1:56	57	89	388	1510	298	213.9		
17:14	1:58	59	90	400	1506	307	220.4		
17:16	2:00	65	91	400	1517	284	203.9		
17:18	2:02	59	90	391	1512	288	206.7		
17:20	2:04	54	89	389	1517	298	213.9		
17:22	2:06	57	91	386	1509	305	218.9		
17:24	2:08	56	90	392	1512	274	196.7		
17:26	2:10	55	89	389	1516	300	215.3		
17:28	2:12	65	90	401	1514	310	222.5		
17:30	2:14	60	90	388	1521	277	198.8		
17:32	2:16	64	89	382	1510	289	207.5		
17:34	2:18	62	90	395	1512	308	221.1		
17:36	2:20	55	91	393	1511	291	208.9		
17:38	2:22	64	90	398	1519	276	198.1		
17:40	2:24	60	89	389	1503	303	217.5		
17:42	2:26	60	90	390	1510	309	221.8		
17:44	2:28	60	90	395	1513	281	201.7		
17:46	2:30	54	89	397	1507	294	211.0		
17:48	2:32	57	89	400	1519	304	218.2		
17:50	2:34	60	91	390	1510	291	208.9		
17:52	2:36	55	90	383	1515	277	198.8		
17:54	2:38	56	89	380	1517	304	218.2		
17:56	2:40	56	91	390	1507	304	218.2		
17:58	2:43	59	91	390	1512	285	204.6		
18:00	2:45	56	91	388	1516	276	198.1		
18:02	2:47	56	89	392	1515	295	211.8		
18:04	2:49	58	90	397	1517	301	216.1		
18:06	2:51	57	91	376	1515	289	207.5		
18:08	2:53	57	90	386	1512	271	194.5		
18:10	2:55	61	89	396	1517	297	213.2		
18:12	2:57	58	90	392	1509	307	220.4		
18:14	2:59	58	90	380	1512	282	202.4		
18:16	3:01	62	89	397	1513	298	213.9	End Steady-state	

MATR_16.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
Steady-state Avg.		59	90	391	1512	292	209		
Maximum		65	91	402	1523	310	223		
Minimum		54	89	374	1500	264	190		
Standard Deviation		3.2	0.8	6.9	4.9	12.4	8.9		
TEST CONDITIONS: MATR_16.XLS				Temp. = 90°F					
				Press. = 60 psig					
Date Run: 16-May-96				Rotor = 1500 rpm					
				Solids = 15 wt%					
				Flow = 400 L/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
20:44	0:00	62	62	326	997	152	109.1		
20:46	0:02	66	62	306	998	156	112.0		
20:48	0:04	55	61	304	995	153	109.8		
20:50	0:06	57	61	309	996	151	108.4		
20:52	0:08	68	60	307	994	150	107.7		
20:54	0:10	58	60	306	996	149	107.0		
20:57	0:12	61	60	305	1005	148	106.2		
20:59	0:14	53	60	302	994	149	107.0		
21:01	0:16	68	60	303	995	147	105.5		
21:03	0:18	59	60	301	1002	147	105.5		
21:05	0:20	66	61	302	996	146	104.8		
21:07	0:22	61	60	305	1004	144	103.4		
21:09	0:24	56	60	296	999	149	107.0		
21:11	0:26	60	60	304	997	147	105.5		
21:13	0:28	58	61	310	996	146	104.8		
21:15	0:30	53	60	299	994	143	102.6		
21:17	0:32	58	60	300	995	145	104.1		
21:19	0:34	59	61	303	994	147	105.5		
21:21	0:36	61	60	297	993	144	103.4		
21:23	0:38	60	60	299	995	141	101.2		
21:25	0:40	57	60	298	996	147	105.5		
21:27	0:42	57	60	305	999	142	101.9		
21:29	0:44	57	60	303	994	143	102.6		
21:31	0:46	61	61	304	992	144	103.4		
21:33	0:48	62	61	293	997	142	101.9		
21:35	0:50	58	60	306	997	141	101.2		
21:37	0:52	54	61	293	996	142	101.9		
21:39	0:54	58	60	290	994	145	104.1		
21:41	0:56	52	60	292	992	140	100.5		
21:43	0:58	59	61	301	997	144	103.4		
21:45	1:00	60	60	298	997	143	102.6		
21:47	1:02	61	61	296	1001	140	100.5		
21:49	1:04	53	60	285	995	141	101.2		
21:51	1:06	54	60	307	993	140	100.5		
21:53	1:08	61	60	307	999	145	104.1		
21:55	1:10	54	61	296	997	139	99.8		
21:57	1:12	53	61	309	993	138	99.1		
21:59	1:14	58	61	292	999	138	99.1		
22:01	1:16	53	60	298	995	136	97.6		
22:03	1:18	55	60	297	1004	135	96.9		
22:05	1:20	67	60	292	998	141	101.2		
22:07	1:22	60	61	292	1005	137	98.3		
22:09	1:24	53	60	309	993	136	97.6		
22:11	1:26	59	61	293	993	136	97.6		
22:13	1:28	52	60	297	994	135	96.9		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
22:15	1:30	54	60	308	997	137	98.3		
22:17	1:32	61	61	303	997	135	96.9		
22:19	1:34	67	60	298	996	134	96.2		
22:21	1:36	59	61	305	994	134	96.2		
22:23	1:38	57	60	295	994	136	97.6		
22:25	1:40	54	61	311	996	134	96.2		
22:27	1:42	56	60	305	1005	135	96.9		
22:29	1:44	64	60	311	1000	133	95.5		
22:31	1:46	56	60	296	997	132	94.8		
22:33	1:48	56	60	305	1001	137	98.3		
22:35	1:50	52	60	303	994	138	99.1		
22:37	1:52	55	61	305	997	133	95.5		
22:39	1:54	58	61	308	995	133	95.5		
22:41	1:56	65	60	295	995	133	95.5		
22:43	1:58	67	61	296	1001	133	95.5		
22:45	2:00	57	60	293	996	131	94.0	Begin Steady-state	
22:47	2:02	53	60	297	995	132	94.8		
22:49	2:04	57	60	296	993	134	96.2		
22:51	2:06	54	60	296	997	137	98.3		
22:53	2:08	57	61	303	997	132	94.8		
22:55	2:10	57	61	308	998	132	94.8		
22:57	2:12	53	60	299	998	130	93.3		
22:59	2:14	60	61	303	997	131	94.0		
23:01	2:17	67	60	290	996	131	94.0		
23:04	2:19	59	59	302	1001	135	96.9		
23:06	2:21	61	61	298	1004	131	94.0		
23:08	2:23	54	61	295	999	129	92.6		
23:10	2:25	54	60	299	1000	129	92.6		
23:12	2:27	59	60	301	998	129	92.6		
23:14	2:29	66	60	300	997	127	91.2		
23:16	2:31	53	60	292	995	126	90.4		
23:18	2:33	60	60	298	1008	128	91.9		
23:20	2:35	59	60	290	997	133	95.5		
23:22	2:37	66	61	305	996	130	93.3		
23:24	2:39	59	61	306	994	128	91.9		
23:26	2:41	66	60	280	994	127	91.2		
23:28	2:43	52	60	300	1011	129	92.6		
23:30	2:45	57	60	299	997	130	93.3		
23:32	2:47	55	60	297	997	128	91.9		
23:34	2:49	52	60	303	996	127	91.2		
23:36	2:51	53	60	292	994	127	91.2		
23:38	2:53	55	60	297	998	131	94.0		
23:40	2:55	56	60	303	997	129	92.6		
23:42	2:57	54	60	283	994	126	90.4		
23:44	2:59	58	60	298	996	127	91.2		
23:46	3:01	60	60	296	994	127	91.2		
23:48	3:03	51	60	296	999	129	92.6		
23:50	3:05	50	61	296	996	126	90.4		
23:52	3:07	53	60	303	998	127	91.2		
23:54	3:09	66	60	296	995	124	89.0		

MATR_17.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
23:56	3:11	51	60	292	996	131	94.0		
23:58	3:13	62	60	304	994	126	90.4		
0:00	3:15	54	61	288	996	126	90.4		
0:02	3:17	53	61	295	994	126	90.4		
0:04	3:19	54	60	291	993	125	89.7		
0:06	3:21	56	60	283	995	130	93.3		
0:08	3:23	59	61	301	997	125	89.7		
0:10	3:25	59	60	296	995	126	90.4		
0:12	3:27	55	60	308	995	125	89.7		
0:14	3:29	64	60	299	995	125	89.7		
0:16	3:31	58	60	305	1000	130	93.3		
0:18	3:33	63	61	297	997	125	89.7		
0:20	3:35	52	61	295	997	124	89.0		
0:22	3:37	55	60	290	997	124	89.0		
0:24	3:39	56	60	295	997	124	89.0		
0:26	3:41	55	60	291	994	123	88.3		
0:28	3:43	65	60	285	1006	128	91.9		
0:30	3:45	52	61	289	994	124	89.0		
0:32	3:47	55	60	290	996	123	88.3		
0:34	3:49	56	60	295	996	124	89.0		
0:36	3:51	51	60	303	997	127	91.2		
0:38	3:53	59	61	291	995	124	89.0		
0:40	3:55	51	60	297	995	123	88.3		
0:42	3:57	59	60	301	996	124	89.0		
0:44	3:59	57	60	301	995	127	91.2		
0:46	4:01	58	61	293	998	124	89.0	End Steady-state	
Steady-state Avg.		57	60	296	997	128	92		
Maximum		67	61	308	1011	137	98		
Minimum		50	59	280	993	123	88		
Standard Deviation		4.4	0.5	6.1	3.3	3.2	2.3		
TEST CONDITIONS: MATR_17.XLS					Temp. = 60°F				
					Press. = 60 psig				
Date Run: 16,17-May-96					Rotor = 1000 rpm				
					Solids = 15 wt%				
					Flow = 300 L/hr				

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
3:23	0:00	84	90	275	997	247	177.3		
3:25	0:02	79	90	272	995	226	162.2		
3:27	0:04	74	88	265	993	242	173.7		
3:29	0:06	78	88	291	993	232	166.5		
3:31	0:08	83	88	288	995	233	167.3		
3:33	0:10	74	88	296	996	238	170.8		
3:35	0:12	70	88	293	997	238	170.8		
3:37	0:14	82	88	285	996	233	167.3		
3:39	0:16	80	88	292	995	237	170.1		
3:41	0:18	75	88	284	996	240	172.3		
3:43	0:20	73	89	282	993	237	170.1		
3:45	0:22	81	89	284	994	237	170.1		
3:47	0:24	81	89	289	995	234	168.0		
3:49	0:26	81	89	284	997	236	169.4		
3:51	0:28	82	89	289	994	240	172.3		
3:53	0:30	77	89	280	993	239	171.6		
3:55	0:32	80	89	288	996	241	173.0		
3:57	0:34	74	89	283	993	237	170.1		
3:59	0:36	73	89	286	1005	241	173.0		
4:01	0:38	82	89	285	995	240	172.3		
4:03	0:40	78	89	281	994	239	171.6		
4:05	0:42	79	89	278	996	236	169.4		
4:07	0:44	77	89	286	997	232	166.5		
4:09	0:46	75	90	283	995	238	170.8		
4:11	0:48	76	90	281	996	237	170.1		
4:13	0:50	76	89	281	992	229	164.4		
4:15	0:52	84	89	277	995	231	165.8		
4:17	0:54	82	89	280	994	230	165.1		
4:19	0:56	85	89	280	997	236	169.4		
4:21	0:58	74	89	278	997	231	165.8		
4:23	1:00	80	89	276	993	233	167.3		
4:25	1:02	72	89	281	993	235	168.7		
4:27	1:04	72	89	278	994	233	167.3		
4:29	1:06	72	90	279	996	239	171.6		
4:31	1:08	73	89	278	993	238	170.8		
4:33	1:10	75	89	279	994	235	168.7		
4:35	1:12	81	90	284	994	238	170.8		
4:37	1:14	72	90	282	996	235	168.7		
4:39	1:16	81	90	279	994	232	166.5		
4:41	1:18	81	90	278	996	226	162.2		
4:43	1:20	75	89	276	992	231	165.8		
4:45	1:22	73	88	276	997	235	168.7		
4:47	1:24	73	89	280	997	232	166.5		
4:49	1:26	73	89	286	997	229	164.4		
4:51	1:28	80	89	272	994	234	168.0		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
4:53	1:30	83	89	279	1000	232	166.5		
4:55	1:32	81	89	275	999	234	168.0		
4:57	1:34	77	89	279	992	234	168.0		
4:59	1:36	85	89	278	998	229	164.4		
5:01	1:38	73	89	280	993	231	165.8		
5:03	1:40	75	90	279	997	231	165.8		
5:05	1:42	76	89	271	996	231	165.8		
5:07	1:44	78	90	280	993	236	169.4		
5:09	1:46	74	90	276	997	235	168.7		
5:11	1:48	81	90	275	995	231	165.8		
5:13	1:50	73	89	274	992	216	155.1	Begin Steady-state	
5:15	1:52	85	89	273	999	225	161.5		
5:18	1:54	81	88	275	996	229	164.4		
5:20	1:56	85	88	278	994	228	163.7		
5:22	1:58	72	89	276	994	224	160.8		
5:24	2:00	82	88	278	994	225	161.5		
5:26	2:02	74	89	277	999	226	162.2		
5:28	2:04	80	89	272	994	227	162.9		
5:30	2:06	85	89	273	994	229	164.4		
5:32	2:08	79	89	275	996	227	162.9		
5:34	2:10	78	89	275	995	225	161.5		
5:36	2:12	81	89	274	996	226	162.2		
5:38	2:14	82	89	280	996	228	163.7		
5:40	2:16	82	90	274	997	230	165.1		
5:42	2:18	77	89	275	993	227	162.9		
5:44	2:20	83	90	277	996	225	161.5		
5:46	2:22	80	90	277	995	230	165.1		
5:48	2:24	73	89	276	996	219	157.2		
5:50	2:26	83	89	277	997	224	160.8		
5:52	2:28	78	89	272	997	227	162.9		
5:54	2:30	83	89	278	993	226	162.2		
5:56	2:32	82	89	278	993	226	162.2		
5:58	2:34	73	89	276	994	226	162.2		
6:00	2:36	74	89	274	997	226	162.2		
6:02	2:38	77	89	276	993	225	161.5		
6:04	2:40	76	89	275	996	226	162.2		
6:06	2:43	82	90	274	997	226	162.2		
6:08	2:45	75	90	274	995	225	161.5		
6:10	2:47	75	90	274	994	226	162.2		
6:12	2:49	72	90	275	997	222	159.4		
6:14	2:51	79	90	269	993	206	147.9		
6:16	2:53	73	88	279	994	220	157.9		
6:18	2:55	83	88	278	995	217	155.8		
6:20	2:57	73	88	274	995	221	158.6		
6:22	2:59	84	89	273	997	221	158.6		
6:24	3:01	71	89	271	997	224	160.8		
6:26	3:03	80	89	278	997	218	156.5		
6:28	3:05	73	89	277	995	221	158.6		
6:30	3:07	75	89	270	996	224	160.8		
6:32	3:09	76	89	272	998	221	158.6		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
6:34	3:11	78	90	278	997	223	160.1		
6:36	3:13	75	90	276	995	222	159.4		
6:38	3:15	79	90	274	996	223	160.1		
6:40	3:17	74	90	278	994	223	160.1		
6:42	3:19	72	90	276	997	221	158.6		
6:44	3:21	77	90	278	994	221	158.6		
6:46	3:23	72	90	279	993	223	160.1		
6:48	3:25	78	89	271	997	209	150.0		
6:50	3:27	85	88	276	995	220	157.9		
6:52	3:29	75	88	275	994	220	157.9		
6:54	3:31	71	89	273	992	217	155.8		
6:56	3:33	81	89	272	997	221	158.6		
6:57	3:34	78	89	275	994	219	157.2	End Steady-state	
Steady-state Avg.		78	89	275	995	223	160		
Maximum		85	90	280	999	230	165		
Minimum		71	88	269	992	206	148		
Standard Deviation		4.3	0.7	2.5	1.7	4.6	3.3		
TEST CONDITIONS: MATR_18.XLS				Temp. = 90°F					
				Press. = 75 psig					
Date Run: 17-May-96				Rotor = 1000 rpm					
				Solids = 15 wt%					
				Flow = 300 L/hr					

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
7:36	0:00	60	90	289	1506	265	190.2		
7:38	0:02	63	90	287	1507	249	178.7		
7:40	0:04	59	88	291	1502	260	186.6		
7:42	0:06	62	89	287	1497	271	194.5		
7:44	0:08	64	90	290	1503	283	203.1		
7:46	0:10	63	91	295	1493	257	184.5		
7:48	0:12	66	89	295	1503	274	196.7		
7:50	0:14	58	89	292	1503	281	201.7		
7:52	0:16	59	90	297	1491	288	206.7		
7:54	0:18	71	90	288	1491	260	186.6		
7:56	0:20	66	89	293	1494	275	197.4		
7:58	0:22	57	89	291	1501	289	207.5		
8:00	0:24	66	90	293	1499	280	201.0	Begin Steady-state	
8:02	0:26	67	90	293	1497	260	186.6		
8:04	0:28	74	89	285	1505	286	205.3		
8:06	0:30	56	90	288	1503	294	211.0		
8:08	0:32	68	90	291	1507	278	199.6		
8:10	0:34	60	90	302	1504	247	177.3		
8:12	0:36	60	89	304	1499	274	196.7		
8:14	0:38	54	90	306	1503	284	203.9		
8:16	0:40	61	91	306	1506	270	193.8		
8:18	0:42	53	90	306	1505	252	180.9		
8:20	0:44	60	89	305	1506	273	196.0		
8:22	0:46	53	90	306	1494	275	197.4		
8:24	0:48	54	90	309	1502	271	194.5		
8:26	0:50	60	89	305	1491	253	181.6		
8:28	0:52	63	89	310	1490	272	195.2		
8:30	0:54	61	90	316	1489	288	206.7		
8:32	0:56	55	91	304	1491	255	183.0		
8:34	0:58	63	89	304	1501	269	193.1		
8:36	1:00	52	89	312	1505	281	201.7		
8:38	1:02	54	90	301	1497	288	206.7		
8:40	1:04	53	91	309	1503	263	188.8		
8:42	1:06	60	89	310	1503	269	193.1		
8:44	1:08	52	89	308	1497	281	201.7		
8:46	1:10	63	90	307	1503	287	206.0		
8:48	1:12	61	90	303	1497	261	187.4		
8:50	1:14	58	89	305	1504	272	195.2		
8:52	1:16	56	89	299	1499	285	204.6		
8:55	1:18	69	90	309	1496	295	211.8		
8:57	1:20	63	90	305	1498	260	186.6		
8:59	1:22	55	89	308	1502	288	206.7		
9:01	1:24	69	89	306	1492	276	198.1		
9:03	1:26	53	90	309	1496	283	203.1		
9:05	1:28	62	90	308	1489	261	187.4		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
9:07	1:30	63	89	300	1505	283	203.1		
9:09	1:32	52	89	315	1503	290	208.2		
9:11	1:34	52	91	308	1491	270	193.8		
9:13	1:36	54	89	302	1506	262	188.1		
9:15	1:38	57	89	308	1496	282	202.4		
9:17	1:40	54	90	308	1500	288	206.7		
9:19	1:42	64	90	313	1500	287	206.0		
9:21	1:44	63	90	307	1503	250	179.5		
9:23	1:46	54	88	308	1506	281	201.7		
9:25	1:48	66	90	312	1495	288	206.7		
9:27	1:50	69	90	311	1501	294	211.0		
9:29	1:52	63	90	306	1503	257	184.5		
9:31	1:54	62	88	307	1502	283	203.1		
9:33	1:56	57	89	301	1501	296	212.5		
9:35	1:58	59	90	314	1505	301	216.1		
9:37	2:00	55	91	309	1490	260	186.6		
9:39	2:02	65	89	303	1493	276	198.1		
9:41	2:04	54	89	308	1501	294	211.0		
9:43	2:06	52	90	304	1500	295	211.8		
9:45	2:08	53	90	306	1502	289	207.5		
9:47	2:10	69	90	307	1495	260	186.6		
9:49	2:12	53	88	303	1503	290	208.2		
9:51	2:14	62	89	304	1503	299	214.6		
9:53	2:16	52	90	300	1496	305	218.9		
9:55	2:18	58	90	303	1499	265	190.2		
9:57	2:20	53	89	304	1489	291	208.9		
9:59	2:22	68	89	308	1490	298	213.9		
10:01	2:24	55	90	307	1502	304	218.2		
10:03	2:26	52	91	316	1503	265	190.2	End Steady-state	
Steady-state Avg.		59	90	305	1499	278	200		
Maximum		74	91	316	1507	305	219		
Minimum		52	88	285	1489	247	177		
Standard Deviation		5.8	0.7	6.0	5.2	14.7	10.5		
TEST CONDITIONS: MATR_19.XLS					Temp. = 90°F				
					Press. = 60 psig				
Date Run: 17-May-96					Rotor = 1500 rpm				
					Solids = 15 wt%				
					Flow = 300 L/hr				

SpinTek II High Shear Rotary Membrane System

StreamScan™										
TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX			
11:15	0:00	45	61	311	1501	162	116.3			
11:17	0:02	42	61	311	1503	162	116.3			
11:19	0:04	44	61	298	1504	163	117.0			
11:21	0:06	42	60	313	1496	161	115.6			
11:23	0:08	49	61	306	1500	161	115.6			
11:25	0:10	41	61	307	1500	164	117.7			
11:27	0:12	42	61	306	1505	161	115.6			
11:29	0:14	42	60	317	1492	161	115.6			
11:31	0:16	43	60	294	1503	168	120.6			
11:33	0:18	50	60	284	1502	171	122.7			
11:35	0:20	39	60	318	1498	137	98.3			
11:37	0:22	43	60	306	1502	156	112.0	Begin Steady-state		
11:39	0:24	48	61	315	1503	158	113.4			
11:41	0:26	40	60	308	1496	155	111.3			
11:43	0:28	43	60	310	1503	159	114.1			
11:45	0:30	44	60	314	1509	159	114.1			
11:47	0:32	44	60	315	1501	154	110.5			
11:49	0:34	40	60	309	1504	158	113.4			
11:51	0:36	43	60	295	1499	160	114.9			
11:53	0:38	43	61	308	1504	157	112.7			
11:55	0:40	39	60	314	1497	157	112.7			
11:57	0:42	44	60	308	1497	159	114.1			
11:59	0:44	41	60	313	1511	157	112.7			
12:01	0:46	47	60	306	1503	157	112.7			
12:03	0:48	40	61	306	1503	159	114.1			
12:05	0:50	39	60	312	1501	158	113.4			
12:07	0:52	40	60	303	1499	156	112.0			
12:09	0:54	48	60	307	1501	157	112.7			
12:11	0:56	43	60	305	1504	159	114.1			
12:13	0:58	47	60	313	1503	157	112.7			
12:15	1:00	44	60	303	1504	155	111.3			
12:17	1:02	39	60	301	1503	157	112.7			
12:19	1:04	44	60	314	1502	161	115.6			
12:21	1:06	42	60	308	1491	158	113.4			
12:23	1:08	39	60	303	1503	160	114.9			
12:25	1:10	48	60	301	1499	158	113.4			
12:27	1:12	46	60	314	1504	158	113.4			
12:29	1:14	40	60	321	1510	156	112.0			
12:31	1:16	46	61	318	1508	158	113.4			
12:33	1:18	42	60	308	1501	158	113.4			
12:35	1:20	43	60	299	1499	158	113.4			
12:37	1:22	42	60	311	1498	158	113.4			
12:39	1:24	42	60	290	1503	159	114.1			
12:41	1:26	41	61	307	1495	158	113.4			
12:43	1:28	47	61	307	1499	159	114.1			

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
12:45	1:30	40	61	319	1502	158	113.4		
12:47	1:32	40	60	300	1503	158	113.4		
12:49	1:34	40	60	301	1501	159	114.1		
12:51	1:36	44	60	312	1496	158	113.4		
12:53	1:38	39	60	312	1495	157	112.7		
12:55	1:40	44	60	294	1503	156	112.0		
12:57	1:42	47	60	318	1496	159	114.1		
12:59	1:44	44	61	305	1489	160	114.9		
13:01	1:46	39	61	298	1503	161	115.6		
13:03	1:48	39	60	313	1503	160	114.9		
13:05	1:50	41	60	304	1502	160	114.9		
13:08	1:52	43	60	305	1498	158	113.4		
13:10	1:54	41	60	307	1500	160	114.9		
13:12	1:56	42	60	315	1501	160	114.9		
13:14	1:58	43	60	307	1498	158	113.4		
13:16	2:00	41	60	310	1500	159	114.1		
13:18	2:02	44	60	307	1501	159	114.1		
13:20	2:04	43	60	295	1500	160	114.9		
13:22	2:06	44	60	303	1501	158	113.4		
13:24	2:08	40	60	309	1499	158	113.4		
13:26	2:10	41	60	296	1508	159	114.1		
13:28	2:12	44	61	300	1500	160	114.9		
13:30	2:14	39	61	303	1490	160	114.9		
13:32	2:16	41	61	305	1496	160	114.9		
13:34	2:18	43	60	296	1497	157	112.7		
13:36	2:20	44	60	306	1499	161	115.6		
13:38	2:22	48	61	317	1506	161	115.6		
13:40	2:24	41	61	310	1491	160	114.9	End Steady-state	
Steady-state Avg.		43	60	307	1501	158	114		
Maximum		48	61	321	1511	161	116		
Minimum		39	60	290	1489	154	111		
Standard Deviation		2.7	0.4	6.7	4.4	1.6	1.1		
TEST CONDITIONS: MATR_20.XLS									
				Temp. =	60 F				
				Press. =	45 psig				
Date Run: 17-May-96				Rotor =	1500 rpm				
				Solids =	15 wt%				
				Flow =	400 L/hr				

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
15:04	0:00	57	62	269	1499	227	162.9		
15:06	0:02	52	62	269	1496	223	160.1		
15:08	0:04	55	62	266	1500	221	158.6		
15:10	0:06	51	62	267	1501	219	157.2		
15:12	0:08	58	62	267	1493	216	155.1		
15:14	0:10	55	61	268	1490	217	155.8		
15:16	0:12	52	62	269	1499	214	153.6		
15:18	0:14	65	62	265	1503	213	152.9		
15:20	0:16	51	62	268	1489	212	152.2		
15:22	0:18	59	62	266	1500	210	150.7		
15:24	0:20	65	62	269	1494	210	150.7		
15:26	0:22	58	61	270	1503	207	148.6		
15:28	0:24	68	62	268	1502	208	149.3		
15:30	0:26	64	62	263	1503	207	148.6		
15:32	0:28	65	62	266	1499	203	145.7		
15:34	0:30	55	62	268	1505	204	146.4		
15:36	0:32	63	62	267	1503	202	145.0		
15:38	0:34	55	62	263	1496	203	145.7		
15:40	0:36	66	62	268	1498	200	143.6		
15:42	0:38	52	62	264	1489	201	144.3		
15:44	0:40	54	61	272	1498	203	145.7		
15:46	0:42	67	62	268	1495	201	144.3		
15:48	0:44	55	61	264	1496	197	141.4	Begin Steady-state	
15:50	0:46	58	60	268	1501	197	141.4		
15:52	0:48	54	62	264	1497	200	143.6		
15:54	0:50	63	61	268	1502	199	142.8		
15:56	0:52	67	61	268	1500	199	142.8		
15:58	0:54	67	61	263	1499	200	143.6		
16:00	0:56	59	62	268	1499	197	141.4		
16:02	0:58	58	61	267	1489	201	144.3		
16:04	1:00	57	60	265	1498	199	142.8		
16:06	1:02	55	61	270	1496	198	142.1		
16:08	1:04	59	61	266	1498	197	141.4		
16:10	1:06	56	61	266	1499	197	141.4		
16:12	1:08	56	60	267	1501	195	140.0		
16:14	1:10	59	61	262	1495	194	139.3		
16:16	1:12	55	62	266	1493	196	140.7		
16:18	1:14	65	62	266	1502	195	140.0		
16:20	1:16	59	61	262	1496	198	142.1		
16:22	1:18	59	60	271	1494	194	139.3		
16:24	1:20	57	61	266	1503	196	140.7		
16:26	1:22	55	61	266	1499	194	139.3		
16:28	1:24	60	61	269	1496	197	141.4		
16:30	1:26	68	60	268	1500	195	140.0		
16:32	1:28	53	61	270	1492	193	138.5		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
16:34	1:30	67	60	267	1490	194	139.3		
16:36	1:32	66	60	265	1495	196	140.7		
16:38	1:34	67	60	266	1497	197	141.4		
16:40	1:36	62	60	263	1498	196	140.7		
16:42	1:38	59	60	267	1497	194	139.3		
16:45	1:40	53	61	263	1503	195	140.0		
16:47	1:42	55	60	266	1500	194	139.3		
16:49	1:44	56	60	265	1498	193	138.5		
16:51	1:46	65	61	263	1501	194	139.3		
16:53	1:48	68	61	269	1494	193	138.5		
16:55	1:50	55	60	265	1496	191	137.1		
16:57	1:52	54	61	265	1498	198	142.1		
16:59	1:54	54	61	273	1497	192	137.8		
17:01	1:56	57	61	269	1495	194	139.3		
17:03	1:58	53	61	266	1500	196	140.7		
17:05	2:00	53	61	268	1504	193	138.5		
17:07	2:02	57	61	267	1503	193	138.5		
17:09	2:04	59	61	267	1502	195	140.0		
17:11	2:06	54	61	264	1497	193	138.5		
17:13	2:08	60	61	267	1491	194	139.3		
17:15	2:10	56	60	268	1498	196	140.7		
17:17	2:12	59	61	266	1496	192	137.8		
17:19	2:14	59	60	269	1496	191	137.1		
17:21	2:16	67	63	263	1499	191	137.1		
17:23	2:18	67	63	265	1501	193	138.5		
17:25	2:20	54	62	270	1503	193	138.5		
17:27	2:22	58	62	264	1494	193	138.5		
17:29	2:24	56	62	262	1499	194	139.3		
17:31	2:26	53	62	265	1504	192	137.8		
17:33	2:28	58	62	269	1499	195	140.0		
17:35	2:30	67	63	268	1501	192	137.8	End Steady-state	
Steady-state Avg.		59	61	266	1498	195	140		
Maximum		68	63	273	1504	201	144		
Minimum		53	60	262	1489	191	137		
Standard Deviation		4.8	0.8	2.4	3.5	2.5	1.8		
TEST CONDITIONS: MATR_21.XLS					Temp. =	60 F			
					Press. =	60 psig			
Run Date: 17-May-96					Rotor =	1500 rpm			
					Solids =	1 wt%			
					Flow =	400 L/hr			

SpinTek II High Shear Rotary Membrane System

StreamScan™

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
18:31	0:00	80	90	194	2010	467	335.2		
18:32	0:00	77	90	193	2016	493	353.9		
18:34	0:02	75	91	190	2016	461	330.9		
18:36	0:04	77	89	242	2020	405	290.7		
18:38	0:06	73	88	241	2008	459	329.5		
18:40	0:08	70	90	241	2011	484	347.4		
18:42	0:10	70	90	244	2016	489	351.0		
18:44	0:12	70	90	240	2019	421	302.2		
18:46	0:14	78	89	244	2016	446	320.2		
18:48	0:16	84	88	240	2009	440	315.8		
18:50	0:18	83	90	239	2012	444	318.7		
18:52	0:20	84	91	243	2016	449	322.3		
18:54	0:22	80	90	240	2014	429	307.9		
18:56	0:24	71	88	241	2016	455	326.6		
18:58	0:26	75	90	245	2009	471	338.1		
19:00	0:29	83	91	244	2005	496	356.0		
19:02	0:31	78	90	240	2012	410	294.3		
19:04	0:33	71	89	239	2017	442	317.3	Begin Steady-state	
19:06	0:34	74	89	244	2010	482	346.0		
19:08	0:37	75	90	241	2011	480	344.6		
19:10	0:39	76	90	240	2015	443	318.0		
19:12	0:41	77	89	243	2016	444	318.7		
19:14	0:43	66	88	240	2009	473	339.5		
19:16	0:45	69	90	241	2015	469	336.7		
19:18	0:47	78	91	243	2011	453	325.2		
19:20	0:49	84	91	240	2014	412	295.7		
19:22	0:51	69	89	244	2012	458	328.8		
19:24	0:53	77	89	247	2010	468	335.9		
19:26	0:55	69	91	243	2014	485	348.1		
19:28	0:57	78	93	243	2024	424	304.4		
19:30	0:59	73	91	237	2013	406	291.4		
19:32	1:01	69	89	238	2020	421	302.2		
19:34	1:03	76	88	240	2009	474	340.3		
19:36	1:05	68	89	239	2013	449	322.3		
19:38	1:07	73	90	237	2016	477	342.4		
19:40	1:09	66	90	240	2011	424	304.4		
19:42	1:11	76	89	240	2016	438	314.4		
19:44	1:13	69	88	239	2016	478	343.1		
19:46	1:15	71	89	238	2025	467	335.2		
19:48	1:17	70	90	242	2016	463	332.4		
19:50	1:19	66	91	239	2023	461	330.9		
19:52	1:21	67	90	241	2003	419	300.8		
19:54	1:23	69	88	244	2010	467	335.2		
19:56	1:25	71	90	244	2011	477	342.4		
19:58	1:27	84	90	244	2026	499	358.2		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
20:00	1:29	76	91	244	2002	487	349.6		
20:02	1:31	69	90	237	2014	433	310.8		
20:04	1:33	83	89	245	2013	456	327.3		
20:06	1:35	72	89	241	2015	455	326.6		
20:08	1:37	68	90	241	2016	503	361.1		
20:10	1:39	75	91	245	2019	426	305.8		
20:12	1:41	78	89	242	2018	442	317.3		
20:14	1:43	72	88	238	2010	471	338.1		
20:16	1:45	66	89	245	2017	481	345.3		
20:18	1:47	72	90	242	2017	485	348.1		
20:20	1:49	66	90	237	2010	425	305.1		
20:22	1:51	72	90	243	2016	452	324.5		
20:24	1:53	69	88	243	2017	483	346.7		
20:26	1:55	69	90	241	2011	497	356.8		
20:28	1:57	71	90	244	2008	485	348.1		
20:30	1:59	73	91	247	2014	433	310.8		
20:32	2:01	77	88	241	2014	446	320.2		
20:34	2:03	67	88	240	2011	496	356.0		
20:36	2:05	82	89	244	2010	484	347.4		
20:38	2:07	72	91	243	2017	468	335.9		
20:41	2:09	74	90	244	2014	442	317.3		
20:43	2:11	82	89	241	2024	459	329.5		
20:45	2:13	67	89	239	2016	491	352.5		
20:47	2:15	84	91	241	2016	456	327.3		
20:49	2:17	70	91	236	2018	429	307.9		
20:51	2:19	69	90	246	2022	452	324.5		
20:53	2:21	84	89	244	2010	472	338.8		
20:55	2:23	77	91	243	2019	464	333.1		
20:57	2:25	72	91	243	2015	427	306.5		
20:59	2:27	73	89	241	2016	440	315.8		
21:01	2:29	76	89	237	2017	493	353.9		
21:03	2:31	71	90	244	2019	497	356.8		
21:05	2:33	77	92	237	2010	430	308.7		
21:07	2:35	69	91	241	2018	415	297.9		
21:09	2:37	70	88	242	2019	463	332.4		
21:11	2:39	78	89	242	2010	474	340.3		
21:13	2:41	74	91	241	2016	434	311.5		
21:15	2:43	70	90	241	2008	416	298.6		
21:17	2:45	71	89	244	2021	462	331.6		
21:19	2:47	77	90	241	2029	476	341.7		
21:21	2:49	71	92	242	2003	451	323.7		
21:23	2:51	68	91	240	2010	424	304.4		
21:25	2:53	76	89	240	2016	458	328.8		
21:27	2:55	76	89	244	2010	501	359.6		
21:29	2:57	70	91	245	2008	485	348.1		
21:31	2:59	69	91	239	2016	422	302.9		
21:33	3:01	66	90	240	2014	425	305.1		
21:35	3:04	74	89	245	2016	462	331.6	End Steady-state	

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
Steady-state Avg.		73	90	242	2015	458	329		
Maximum		84	93	247	2029	503	361		
Minimum		66	88	236	2002	406	291		
Standard Deviation		4.8	1.1	2.6	5.1	25.3	18.2		
TEST CONDITIONS: MATR_22.XLS				Temp. = 90 F					
				Press. = 75 psig					
Date Run: 17-May-96				Rotor = 2000 rpm					
				Solids = 15 wt%					
				Flow = 400 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
22:40	0:00	56	120	420	1991	630	452.2		
22:42	0:02	57	120	399	1990	500	358.9		
22:44	0:04	52	117	418	1990	625	448.6		
22:46	0:06	52	117	418	1991	619	444.3		
22:48	0:08	59	117	412	1992	603	432.9		
22:50	0:10	62	118	417	1992	546	391.9		
22:52	0:12	54	118	432	1996	621	445.8		
22:55	0:14	56	119	440	1988	572	410.6		
22:57	0:16	52	120	428	1987	616	442.2		
22:59	0:18	57	121	417	1989	566	406.3		
23:01	0:20	62	121	430	1988	547	392.7		
23:03	0:22	59	118	414	2000	618	443.6		
23:05	0:24	54	118	421	2002	573	411.3		
23:07	0:26	53	119	416	1989	641	460.1		
23:09	0:28	52	120	423	1989	586	420.6		
23:11	0:30	67	121	425	1994	631	452.9		
23:13	0:32	59	120	436	1992	518	371.8		
23:15	0:34	55	118	407	1986	591	424.2		
23:17	0:36	54	119	408	1989	597	428.5		
23:19	0:38	57	120	422	1989	600	430.7		
23:21	0:40	54	120	421	1996	618	443.6		
23:23	0:42	57	122	424	1994	564	404.9		
23:25	0:44	64	118	424	1989	587	421.4		
23:27	0:46	61	118	419	2003	606	435.0		
23:29	0:48	65	119	415	1987	613	440.0		
23:31	0:50	58	120	414	2002	585	419.9		
23:33	0:52	56	121	419	1988	602	432.1		
23:35	0:54	58	121	420	1991	548	393.4		
23:37	0:56	54	119	434	1997	580	416.3		
23:39	0:58	53	119	427	1992	619	444.3		
23:41	1:00	67	120	421	1994	596	427.8		
23:43	1:02	54	121	429	1995	670	480.9		
23:45	1:04	60	124	419	1991	566	406.3		
23:47	1:06	54	123	422	1989	517	371.1		
23:49	1:08	54	118	419	1989	615	441.5		
23:51	1:10	61	119	401	1989	600	430.7		
23:53	1:12	52	120	414	1989	565	405.6		
23:55	1:14	52	121	426	1989	581	417.1		
23:57	1:16	53	122	411	2000	536	384.8	Begin Steady-state	
23:59	1:18	56	119	397	1996	556	399.1		
0:00	1:19	55	118	411	1993	541	388.3		
0:02	1:21	64	119	402	1989	568	407.7		
0:04	1:23	52	120	424	1999	596	427.8		
0:06	1:25	61	122	426	1989	491	352.5		
0:08	1:27	59	118	409	1992	540	387.6		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
0:10	1:29	71	118	402	2002	523	375.4		
0:12	1:31	66	119	383	2003	602	432.1		
0:14	1:33	65	120	394	2003	637	457.3		
0:16	1:35	59	122	386	1993	542	389.1		
0:18	1:37	60	118	396	1995	577	414.2		
0:20	1:39	56	118	392	1997	581	417.1		
0:22	1:41	64	119	387	1989	567	407.0		
0:24	1:43	63	121	401	1997	547	392.7		
0:26	1:45	61	122	383	1989	526	377.6		
0:28	1:47	57	118	387	1996	592	425.0		
0:30	1:49	63	119	383	2003	601	431.4		
0:32	1:51	65	119	388	1989	627	450.1		
0:34	1:53	59	121	394	1991	594	426.4		
0:36	1:55	71	121	384	1992	543	389.8		
0:38	1:57	66	119	390	1987	556	399.1		
0:40	1:59	69	118	391	2000	576	413.5		
0:42	2:01	64	119	397	1989	566	406.3		
0:44	2:03	61	120	383	1996	572	410.6		
0:46	2:05	59	121	384	1991	551	395.5		
0:48	2:07	68	119	389	1999	543	389.8		
0:50	2:09	65	118	397	1989	577	414.2		
0:52	2:11	66	120	372	1990	589	422.8		
0:54	2:13	70	121	396	1991	670	480.9		
0:56	2:15	67	121	396	1992	536	384.8		
0:58	2:17	66	120	391	1990	595	427.1		
1:00	2:19	60	121	395	1990	576	413.5		
1:02	2:21	58	121	398	1998	506	363.2		
1:04	2:23	70	119	382	1993	556	399.1		
1:06	2:25	57	119	391	1991	549	394.1		
1:08	2:27	65	120	389	1992	588	422.1		
1:10	2:29	65	122	385	1992	587	421.4		
1:12	2:31	60	120	386	1988	511	366.8		
1:14	2:33	66	119	393	1991	563	404.1		
1:16	2:35	64	120	393	1995	542	389.1		
1:18	2:37	57	120	388	1993	596	427.8		
1:20	2:39	57	121	379	2007	540	387.6		
1:22	2:41	57	119	388	1989	519	372.6		
1:24	2:43	65	119	386	1990	568	407.7		
1:26	2:45	68	119	395	2000	564	404.9		
1:28	2:47	70	120	378	1994	564	404.9		
1:30	2:49	64	121	367	1996	576	413.5		
1:32	2:51	66	119	392	1989	548	393.4		
1:34	2:53	56	118	387	1993	569	408.4		
1:36	2:55	69	120	389	1998	572	410.6		
1:38	2:57	65	120	388	1999	562	403.4		
1:40	2:59	59	121	390	1993	596	427.8		
1:42	3:01	71	122	395	1989	529	379.7		
1:44	3:03	65	119	389	1995	588	422.1		
1:46	3:05	60	119	400	1992	583	418.5		
1:48	3:07	64	121	397	1999	583	418.5		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
1:50	3:09	59	122	387	1989	598	429.3		
1:52	3:11	70	119	389	1989	548	393.4		
1:54	3:13	64	118	393	1991	615	441.5		
1:56	3:15	59	120	388	2002	615	441.5		
1:58	3:17	59	120	392	1997	593	425.7	End Steady-state	
Steady-state Avg.		63	120	392	1994	568	408		
Maximum		71	122	426	2007	670	481		
Minimum		52	118	367	1987	491	352		
Standard Deviation		4.8	1.3	10.0	4.7	32.4	23.2		
TEST CONDITIONS: MATR_23.XLS				Temp. = 120°F					
				Press. = 60 psig					
Date Run: 17,18-May-96				Rotor = 2000 rpm					
				Solids = 15 wt%					
				Flow = 400 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
2:35	0:00	43	120	396	1519	451	323.7		
2:37	0:01	51	121	388	1507	463	332.4		
2:39	0:03	50	119	394	1510	448	321.6		
2:41	0:05	48	117	396	1505	443	318.0		
2:43	0:07	42	118	399	1520	471	338.1		
2:45	0:09	42	118	378	1513	461	330.9		
2:47	0:11	53	118	395	1514	470	337.4		
2:49	0:13	49	118	395	1508	442	317.3		
2:51	0:15	50	119	383	1519	445	319.4		
2:53	0:17	46	119	392	1515	475	341.0		
2:55	0:20	44	120	389	1520	442	317.3		
2:57	0:22	49	120	409	1515	470	337.4		
2:59	0:24	43	121	390	1522	443	318.0		
3:01	0:26	47	120	390	1521	415	297.9		
3:03	0:28	53	118	380	1505	425	305.1		
3:05	0:30	44	118	378	1517	410	294.3		
3:07	0:32	51	119	382	1512	436	313.0		
3:09	0:34	43	119	385	1510	446	320.2		
3:11	0:36	48	119	378	1507	432	310.1		
3:13	0:38	43	119	378	1509	435	312.3		
3:15	0:40	46	119	378	1516	440	315.8		
3:17	0:42	52	120	378	1513	420	301.5		
3:19	0:44	46	120	379	1514	430	308.7		
3:21	0:46	53	120	398	1513	448	321.6		
3:23	0:48	42	120	402	1521	458	328.8		
3:25	0:50	53	120	387	1512	432	310.1		
3:27	0:52	44	121	403	1512	437	313.7		
3:29	0:54	45	121	392	1521	428	307.2		
3:32	0:56	42	120	402	1517	427	306.5		
3:34	0:58	42	119	387	1507	408	292.9		
3:36	1:00	42	119	399	1507	416	298.6		
3:38	1:02	49	119	388	1512	456	327.3		
3:40	1:04	42	120	387	1507	421	302.2		
3:42	1:06	47	120	391	1515	410	294.3		
3:44	1:08	45	120	386	1509	439	315.1		
3:46	1:10	46	121	404	1513	448	321.6		
3:48	1:12	44	121	393	1501	467	335.2		
3:50	1:14	44	121	391	1500	468	335.9		
3:52	1:16	47	120	393	1508	404	290.0	Begin Steady-state	
3:54	1:18	44	119	387	1505	427	306.5		
3:56	1:20	47	119	383	1503	406	291.4		
3:58	1:22	44	119	392	1510	441	316.6		
4:00	1:24	44	120	387	1502	442	317.3		
4:02	1:26	44	120	397	1517	402	288.6		
4:04	1:28	44	120	387	1500	421	302.2		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
4:06	1:30	53	121	393	1507	437	313.7		
4:08	1:32	45	120	390	1505	436	313.0		
4:10	1:34	44	121	379	1499	399	286.4		
4:12	1:36	49	118	390	1510	418	300.1		
4:14	1:38	48	119	379	1510	421	302.2		
4:16	1:40	48	119	391	1503	428	307.2		
4:18	1:42	48	119	383	1509	419	300.8		
4:20	1:44	48	119	397	1503	402	288.6		
4:22	1:46	43	120	404	1512	431	309.4		
4:24	1:48	43	120	392	1505	428	307.2		
4:26	1:50	42	121	395	1504	418	300.1		
4:28	1:52	48	120	392	1500	436	313.0		
4:30	1:54	43	120	383	1503	464	333.1		
4:32	1:56	46	121	383	1514	421	302.2		
4:34	1:58	44	120	389	1507	393	282.1		
4:36	2:00	51	118	394	1510	431	309.4		
4:38	2:02	53	118	385	1515	394	282.8		
4:40	2:04	43	119	406	1510	428	307.2		
4:42	2:06	42	119	388	1504	405	290.7		
4:44	2:08	42	119	387	1510	430	308.7		
4:46	2:10	42	120	399	1507	424	304.4		
4:48	2:12	45	120	398	1502	421	302.2		
4:50	2:14	53	121	402	1501	413	296.5		
4:52	2:16	45	120	401	1511	401	287.8		
4:54	2:18	49	121	400	1508	421	302.2		
4:56	2:20	51	121	385	1503	419	300.8		
4:58	2:22	53	120	385	1502	412	295.7		
5:00	2:24	50	118	378	1504	363	260.6		
5:02	2:26	46	118	399	1504	382	274.2		
5:04	2:28	43	119	393	1506	384	275.6		
5:06	2:30	48	118	392	1505	426	305.8		
5:08	2:32	43	119	391	1508	401	287.8		
5:10	2:34	45	119	391	1503	402	288.6		
5:12	2:36	48	119	373	1518	417	299.3		
5:14	2:38	49	120	370	1506	434	311.5		
5:16	2:40	44	120	387	1508	421	302.2		
5:18	2:42	54	120	401	1510	411	295.0		
5:20	2:44	50	120	386	1508	429	307.9		
5:22	2:46	48	121	388	1509	421	302.2		
5:24	2:48	46	121	375	1511	405	290.7		
5:26	2:50	48	119	380	1500	384	275.6		
5:28	2:52	43	118	374	1505	427	306.5		
5:30	2:54	46	119	394	1518	408	292.9		
5:32	2:56	48	119	386	1512	418	300.1		
5:34	2:59	51	119	393	1510	420	301.5		
5:36	3:01	52	120	377	1502	420	301.5		
5:38	3:03	51	120	373	1504	424	304.4		
5:40	3:05	46	120	395	1509	428	307.2		
5:42	3:07	46	121	375	1513	424	304.4		
5:44	3:09	42	121	376	1507	421	302.2		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
5:46	3:11	49	121	385	1506	428	307.2		
5:48	3:13	45	120	381	1512	388	278.5		
5:50	3:15	42	118	390	1506	412	295.7		
5:52	3:17	52	118	387	1508	381	273.5		
5:54	3:19	52	119	392	1499	415	297.9	End Steady-state	
Steady-state Avg.		47	120	388	1507	416	299		
Maximum		54	121	406	1518	464	333		
Minimum		42	118	370	1499	363	261		
Standard Deviation		3.5	1.0	8.3	4.6	17.4	12.5		
TEST CONDITIONS: MATR_24.XLS				Temp. = 120°F					
				Press. = 45 psig					
Date Run: 18-May-96				Rotor = 1500 rpm					
				Solids = 15 wt%					
				Flow = 400 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
7:48	0:00	80	58	146	1503	238	170.8		
7:50	0:02	80	59	147	1505	244	175.2		
7:52	0:04	65	60	146	1505	244	175.2		
7:54	0:06	66	61	145	1510	228	163.7		
7:56	0:08	73	62	146	1495	230	165.1		
7:58	0:10	77	62	147	1498	223	160.1		
8:00	0:12	75	62	147	1497	227	162.9		
8:02	0:14	79	62	146	1505	224	160.8		
8:04	0:16	71	62	146	1503	227	162.9		
8:06	0:18	72	62	147	1507	221	158.6		
8:08	0:20	71	62	146	1494	228	163.7		
8:10	0:22	69	62	147	1502	225	161.5		
8:12	0:24	74	61	147	1500	218	156.5		
8:14	0:26	76	61	147	1504	226	162.2		
8:16	0:28	70	61	146	1496	226	162.2		
8:18	0:30	66	61	146	1502	220	157.9		
8:20	0:32	82	61	146	1503	225	161.5		
8:22	0:34	72	61	146	1502	222	159.4		
8:24	0:36	77	61	146	1500	221	158.6		
8:26	0:38	82	61	144	1503	220	157.9		
8:28	0:40	76	61	144	1503	223	160.1		
8:30	0:42	81	60	143	1508	222	159.4		
8:32	0:44	76	59	144	1505	230	165.1	Begin Steady-state	
8:35	0:46	75	59	143	1504	239	171.6		
8:37	0:48	68	59	143	1503	238	170.8		
8:39	0:50	81	59	144	1499	238	170.8		
8:41	0:52	75	60	143	1500	236	169.4		
8:43	0:54	72	61	142	1511	231	165.8		
8:45	0:56	73	60	143	1495	229	164.4		
8:47	0:58	72	60	142	1503	218	156.5		
8:49	1:00	69	59	143	1504	225	161.5		
8:51	1:02	81	60	143	1505	234	168.0		
8:53	1:04	69	60	143	1502	240	172.3		
8:55	1:06	68	60	143	1503	221	158.6		
8:57	1:08	68	60	142	1500	222	159.4		
8:59	1:10	68	60	142	1503	215	154.3		
9:01	1:12	68	60	143	1495	229	164.4		
9:03	1:14	80	60	143	1503	237	170.1		
9:05	1:16	67	60	142	1502	234	168.0		
9:07	1:18	65	60	141	1503	223	160.1		
9:09	1:20	64	60	142	1505	217	155.8		
9:11	1:22	68	60	143	1500	232	166.5		
9:13	1:24	75	60	143	1507	227	162.9		
9:15	1:26	69	60	144	1503	235	168.7		
9:17	1:28	74	60	141	1508	228	163.7		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
9:19	1:30	67	60	141	1503	218	156.5		
9:21	1:32	66	60	141	1503	213	152.9		
9:23	1:34	79	60	141	1495	227	162.9		
9:25	1:36	67	60	141	1507	227	162.9		
9:27	1:38	74	60	142	1492	229	164.4		
9:29	1:40	74	60	142	1501	222	159.4		
9:31	1:42	68	60	141	1503	218	156.5		
9:33	1:44	77	60	142	1503	226	162.2		
9:35	1:46	75	60	142	1497	230	165.1		
9:37	1:48	78	60	141	1505	226	162.2		
9:39	1:50	67	60	141	1504	216	155.1		
9:41	1:52	74	60	140	1493	214	153.6		
9:43	1:54	72	59	142	1500	227	162.9		
9:45	1:56	70	60	141	1506	232	166.5		
9:47	1:58	73	60	142	1493	229	164.4		
9:49	2:00	75	60	137	1495	218	156.5		
9:51	2:02	65	60	136	1503	213	152.9		
9:53	2:04	74	60	136	1503	226	162.2		
9:55	2:06	72	60	136	1507	235	168.7		
9:57	2:08	71	60	136	1499	227	162.9		
9:59	2:10	74	60	137	1503	216	155.1		
10:01	2:12	66	60	135	1508	224	160.8		
10:03	2:14	74	60	135	1499	226	162.2		
10:05	2:16	70	60	136	1493	230	165.1		
10:07	2:18	64	61	135	1503	224	160.8		
10:09	2:20	70	61	136	1504	214	153.6		
10:11	2:22	74	60	135	1503	216	155.1		
10:13	2:24	67	60	135	1497	225	161.5		
10:15	2:26	77	60	136	1501	223	160.1		
10:17	2:28	69	60	136	1503	231	165.8		
10:19	2:30	64	61	135	1497	222	159.4		
10:21	2:32	66	60	135	1498	217	155.8		
10:23	2:34	71	60	136	1507	228	163.7		
10:25	2:36	73	60	136	1497	228	163.7		
10:27	2:38	79	60	136	1494	230	165.1		
10:29	2:41	65	60	135	1501	215	154.3		
10:31	2:43	79	60	135	1499	210	150.7		
10:33	2:45	75	59	137	1504	230	165.1	End Steady-state	
Steady-state Avg.		71	60	140	1501	226	162		
Maximum		81	61	144	1511	240	172		
Minimum		64	59	135	1492	210	151		
Standard Deviation		4.6	0.4	3.3	4.3	7.5	5.4		
TEST CONDITIONS: MATR_25.XLS				Temp. = 60 F					
				Press. = 75 psig					
Date Run: 18-May-96				Rotor = 1500 rpm					
				Solids = 15 wt%					
				Flow = 400 L/hr					

SpinTek II High Shear Rotary Membrane System

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
11:57	0:00	46	91	402	1491	254	182.3		
11:59	0:01	52	89	392	1491	258	185.2		
12:01	0:03	54	89	391	1483	266	190.9		
12:03	0:05	52	90	395	1490	269	193.1		
12:05	0:07	45	90	390	1489	248	178.0		
12:07	0:10	48	89	388	1491	265	190.2		
12:09	0:12	49	90	393	1489	271	194.5		
12:11	0:14	48	90	395	1485	269	193.1		
12:13	0:16	48	89	392	1490	257	184.5		
12:15	0:18	45	89	391	1491	268	192.4		
12:17	0:20	40	90	391	1492	273	196.0		
12:19	0:22	47	91	399	1489	253	181.6		
12:21	0:24	42	89	392	1487	267	191.7		
12:23	0:26	49	89	395	1485	274	196.7		
12:25	0:28	40	90	401	1485	277	198.8		
12:27	0:30	41	90	392	1485	253	181.6	Begin Steady-state	
12:29	0:32	54	88	395	1492	268	192.4		
12:31	0:34	45	89	391	1485	271	194.5		
12:33	0:36	40	91	391	1489	259	185.9		
12:35	0:38	45	89	393	1490	262	188.1		
12:37	0:40	44	89	392	1487	271	194.5		
12:39	0:42	44	90	396	1490	278	199.6		
12:41	0:44	41	90	392	1492	250	179.5		
12:43	0:46	43	89	394	1489	272	195.2		
12:45	0:48	41	90	391	1485	275	197.4		
12:47	0:50	43	91	397	1482	259	185.9		
12:49	0:52	40	89	397	1489	267	191.7		
12:51	0:54	47	89	396	1489	273	196.0		
12:53	0:56	47	91	396	1488	271	194.5		
12:55	0:58	43	89	395	1483	263	188.8		
12:57	1:00	49	89	392	1488	273	196.0		
12:59	1:02	44	90	395	1491	277	198.8		
13:01	1:04	44	90	392	1490	256	183.8		
13:03	1:06	51	88	395	1493	269	193.1		
13:05	1:08	53	89	400	1491	274	196.7		
13:07	1:10	52	90	402	1490	260	186.6		
13:09	1:12	41	89	392	1495	268	192.4		
13:11	1:14	48	89	392	1489	273	196.0		
13:13	1:16	40	90	395	1489	278	199.6		
13:15	1:18	51	89	404	1489	257	184.5		
13:17	1:20	48	88	394	1482	275	197.4		
13:19	1:22	43	90	392	1482	273	196.0		
13:21	1:24	45	90	390	1485	257	184.5		
13:23	1:26	45	88	392	1490	268	192.4		
13:25	1:28	50	89	394	1490	277	198.8		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
13:27	1:30	44	91	392	1489	265	190.2		
13:29	1:32	46	89	393	1485	265	190.2		
13:31	1:34	51	89	389	1488	273	196.0		
13:33	1:36	40	90	389	1489	276	198.1		
13:35	1:38	41	90	394	1477	255	183.0		
13:37	1:40	47	88	392	1491	272	195.2		
13:39	1:42	41	89	391	1489	275	197.4		
13:42	1:44	54	90	394	1487	262	188.1		
13:44	1:46	45	89	394	1486	265	190.2		
13:46	1:48	47	89	389	1493	273	196.0		
13:48	1:50	48	90	392	1481	280	201.0		
13:50	1:52	41	90	396	1483	257	184.5		
13:52	1:54	40	88	392	1487	272	195.2		
13:54	1:56	46	89	393	1489	282	202.4		
13:56	1:58	47	90	392	1492	266	190.9		
13:58	2:00	40	89	397	1489	267	191.7		
14:00	2:02	41	89	388	1486	274	196.7		
14:02	2:04	41	90	397	1487	281	201.7		
14:04	2:06	43	90	391	1487	253	181.6		
14:06	2:08	48	88	388	1489	268	192.4		
14:08	2:10	40	89	396	1489	272	195.2		
14:10	2:12	48	90	392	1482	280	201.0		
14:12	2:14	54	89	389	1479	253	181.6		
14:14	2:16	49	89	397	1486	273	196.0		
14:16	2:19	53	90	392	1475	273	196.0		
14:18	2:21	48	90	389	1489	256	183.8		
14:20	2:23	44	88	391	1487	269	193.1		
14:22	2:25	54	89	398	1487	275	197.4		
14:24	2:27	44	91	388	1481	266	190.9		
14:26	2:29	53	89	395	1487	269	193.1		
14:28	2:31	42	90	385	1490	276	198.1		
14:30	2:33	41	91	399	1484	273	196.0		
14:32	2:35	45	89	393	1486	262	188.1		
14:34	2:37	43	89	392	1486	276	198.1	End Steady-state	
Steady-state Avg.		45	89	393	1487	268	193		
Maximum		54	91	404	1495	282	202		
Minimum		40	88	385	1475	250	179		
Standard Deviation		4.3	0.8	3.4	3.8	8.0	5.7		
TEST CONDITIONS: MATR_26.XLS				Temp. =	90 F				
				Press. =	45 psig				
Date Run: 18-May-96				Rotor =	1500 rpm				
				Solids =	1 wt%				
				Flow =	400 L/hr				

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TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
15:13	0:00	58	60	225	2008	234	168.0		
15:15	0:01	67	61	234	2009	224	160.8		
15:17	0:03	65	61	230	2005	213	152.9		
15:19	0:05	53	61	231	2008	220	157.9		
15:21	0:07	50	61	234	2009	225	161.5		
15:23	0:10	50	61	230	2005	229	164.4		
15:25	0:12	49	61	230	2007	223	160.1		
15:27	0:14	53	61	213	2003	250	179.5		
15:29	0:16	53	61	211	2012	229	164.4		
15:31	0:18	53	60	213	2006	240	172.3		
15:33	0:20	51	60	213	2001	256	183.8		
15:35	0:22	67	60	213	2001	247	177.3		
15:37	0:24	54	61	214	2008	232	166.5		
15:39	0:26	56	61	213	2006	233	167.3		
15:41	0:28	67	60	214	2001	237	170.1		
15:43	0:30	55	61	213	2000	251	180.2		
15:45	0:32	58	60	214	2006	247	177.3		
15:47	0:34	54	60	214	2009	230	165.1		
15:49	0:36	57	60	213	2000	238	170.8		
15:51	0:38	61	60	212	2006	230	165.1		
15:53	0:40	53	60	213	2001	237	170.1		
15:55	0:42	53	60	213	2014	259	185.9		
15:57	0:44	57	61	213	2002	230	165.1		
15:59	0:46	55	61	214	2010	229	164.4		
16:01	0:48	60	61	206	2016	232	166.5		
16:03	0:50	69	61	203	2006	247	177.3		
16:05	0:52	58	61	201	2008	254	182.3		
16:07	0:54	54	60	202	2003	251	180.2		
16:09	0:56	68	60	201	2004	238	170.8		
16:11	0:58	54	60	200	2001	256	183.8		
16:13	1:00	56	60	202	2009	249	178.7	Begin Steady-state	
16:15	1:02	60	60	201	2003	252	180.9		
16:17	1:04	60	60	201	2002	249	178.7		
16:19	1:06	55	60	202	2002	246	176.6		
16:21	1:08	54	60	201	2002	249	178.7		
16:23	1:10	60	60	201	2000	245	175.9		
16:25	1:12	54	60	202	2002	251	180.2		
16:27	1:14	65	60	203	2004	244	175.2		
16:29	1:16	62	61	201	2001	248	178.0		
16:31	1:18	52	60	200	1999	245	175.9		
16:33	1:20	52	60	202	2006	252	180.9		
16:35	1:22	54	61	201	2013	249	178.7		
16:37	1:24	68	60	201	2002	244	175.2		
16:39	1:26	60	60	202	2002	253	181.6		
16:41	1:28	55	61	202	1999	253	181.6		

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
16:44	1:30	54	60	201	2013	248	178.0		
16:46	1:32	57	60	200	2007	246	176.6		
16:48	1:34	56	60	202	2002	254	182.3		
16:50	1:36	68	60	202	2015	246	176.6		
16:52	1:38	53	60	201	2002	253	181.6		
16:54	1:40	69	60	202	2010	265	190.2		
16:56	1:42	52	60	202	2009	252	180.9		
16:58	1:44	52	60	201	2005	248	178.0		
17:00	1:46	55	60	202	2005	246	176.6		
17:02	1:48	55	60	203	2005	247	177.3		
17:04	1:50	53	60	201	2002	255	183.0		
17:06	1:52	60	60	202	2002	252	180.9		
17:08	1:54	54	60	202	1998	254	182.3		
17:10	1:56	53	60	202	2002	241	173.0		
17:12	1:58	52	60	201	2003	259	185.9		
17:14	2:00	53	60	202	2004	253	181.6		
17:16	2:02	62	60	201	2017	249	178.7		
17:18	2:04	68	60	201	2003	249	178.7		
17:20	2:06	55	60	201	2007	255	183.0		
17:22	2:08	56	60	200	1999	260	186.6		
17:24	2:10	55	60	201	2019	252	180.9		
17:26	2:12	57	60	201	2023	252	180.9		
17:28	2:14	53	60	201	2003	258	185.2		
17:30	2:16	57	60	201	2006	252	180.9		
17:32	2:18	60	60	201	2000	253	181.6		
17:34	2:20	53	60	201	2011	247	177.3		
17:36	2:22	57	60	202	2002	252	180.9		
17:38	2:24	63	60	201	1990	248	178.0		
17:40	2:26	68	60	201	1996	260	186.6		
17:42	2:28	53	60	200	2000	248	178.0		
17:44	2:30	56	60	200	2001	241	173.0		
17:46	2:32	59	60	201	2000	255	183.0		
17:48	2:35	51	60	201	2002	253	181.6		
17:50	2:36	51	60	200	2000	243	174.4		
17:52	2:39	58	60	201	2019	252	180.9		
17:54	2:41	52	60	202	2010	248	178.0		
17:56	2:43	65	60	201	2001	250	179.5		
17:58	2:45	56	60	200	2002	259	185.9		
18:00	2:47	69	60	201	2010	248	178.0		
18:02	2:49	54	60	201	2012	245	175.9		
18:04	2:51	51	60	201	2000	248	178.0		
18:06	2:53	57	60	201	1999	252	180.9		
18:08	2:55	67	60	201	2011	256	183.8		
18:10	2:57	57	60	201	2002	259	185.9		
18:12	2:59	64	60	200	2000	249	178.7	End Steady-state	

MATR_27.XLS

TIME OF DAY	ELAPSED TIME	FEED PRESSURE	FEED TEMP	FEED FLOW	ROTOR SPEED	PERMEATE FLOW	PERMEATE FLUX		
Steady-state Avg.		57	60	201	2005	251	180		
Maximum		69	61	203	2023	265	190		
Minimum		51	60	200	1990	241	173		
Standard Deviation		5.2	0.2	0.7	6.1	4.9	3.5		
TEST CONDITIONS: MATR_XLS				Temp. =	60 F				
				Press. =	60 psig				
Date Run: 18-May-96				Rotor =	2000 rpm				
				Solids =	15 wt%				
				Flow =	400 L/hr				