BACKFLUSHABLE FILTER TESTS
RADWASTE FLOOR DRAINS AND EQUIPMENT DRAINS
GRAND GULF NUCLEAR STATION

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ABSTRACT

The Grand Gulf Nuclear Station is a twin unit design 1250 MW BWR with unit one in operation. It has two centrifugal discharge precoat type Funda filters to process all liquid radioactive wastes. During plant startup these filters presented major operational and performance problems. Approximately one and a half years were spent modifying both the filter equipment and the operating procedures. In October, 1984 MP&L issued a report which covered the major problems encountered with these filters and provided the basis for the modifications performed to place the filters in to satisfactory service. Since that time, the filter performance has been acceptable and the filters no longer threaten to limit liquid waste processing.

However, the October report indicated that the filter aid use for these filters should be optimized to minimize operating costs. These costs include the purchase of the filter aid material as well as the costs for the packaging, shipment and burial of this contaminated material after its use. Considerable recent effort to optimize the filter aid (Ecodex 203H), has resulted in an average use of 0.67 $ft.^3$ of Ecodex per 1000 gal. of water processed. The test program described in this paper provides data showing that with the appropriate filter system, only 0.036 ft^3 of Ecodex per 1000 gal. of water processed is actually required.

INTRODUCTION

Impell Corporation provides engineering services to the nuclear power industry. In addition to A/E type engineering activity, Impell also provides filtration systems and equipment. New backflushable filter elements developed by Kamer Technology, along with system simplification and improvements designed by Impell, have been undergoing test and demonstration activity since April, 1985. A 250 GPM complete filter system backfit has been delivered to TVA for the Bellefonte Station and a system for the West Valley Demonstration Project has been purchased for installation in mid-1986.

Two complete 10 GPM test systems have been assembled and are presently being used for test and demonstration purposes. One unit is in Atlanta and is used with simulated waste streams to provide design basis information for larger systems. Specific design data being established for particular waste streams include flow rate/ft^2 element area, micron rating required, backflush pressures and volumes required, filtration performance or particulate decontamination factor, backflush sludge handling and sludge dewatering methods.

The second unit was installed as a test system at the Grand Gulf Nuclear Station in early July, 1985. The installation was a simple one day task. The test unit, all interface connections, hoses, tools, cables, a micro computer based data acquisition system and operating procedures were provided by Impell Corporation. The system operation was a joint effort, with Grand Gulf personnel providing the appropriate waste tank valve line-up, tank recirculation and waste tank samples. The filter was operated by Impell personnel with the plant chemistry labs providing sample analysis and support. Plant and nuclear plant engineering personnel also obtained and tabulated operating data from the existing filters for comparison purposes.

As of December, 1985, 85 tests have been conducted. Most all tests have utilized Ecodex 203H; some with just precoat, most with precoat and body feed. Wastes from both the floor drain collector tank and the equipment drain collector tank have been processed. Test parameters have been as follows:

- Flow rate - 2 to 10 GPM
- Clean filter pressure drop - less than 1 psi
- Waste stream pH - 6 to 8
- Waste stream conductivity - 15 to 200 micro mhos
- Total suspended solids (TSS) - 10 to 2000 ppm

Test data recorded on a micro computer based, data acquisition system includes; flow rate, total flow, pressure drop across the filter and waste stream temperature. Liquid samples are taken with a specific sample technique developed for these tests with pH, conductivity and TSS analyzed with standard laboratory techniques. Qualitative particle size distributions and quantities of oil and organics were determined by visual examination with a microscope.

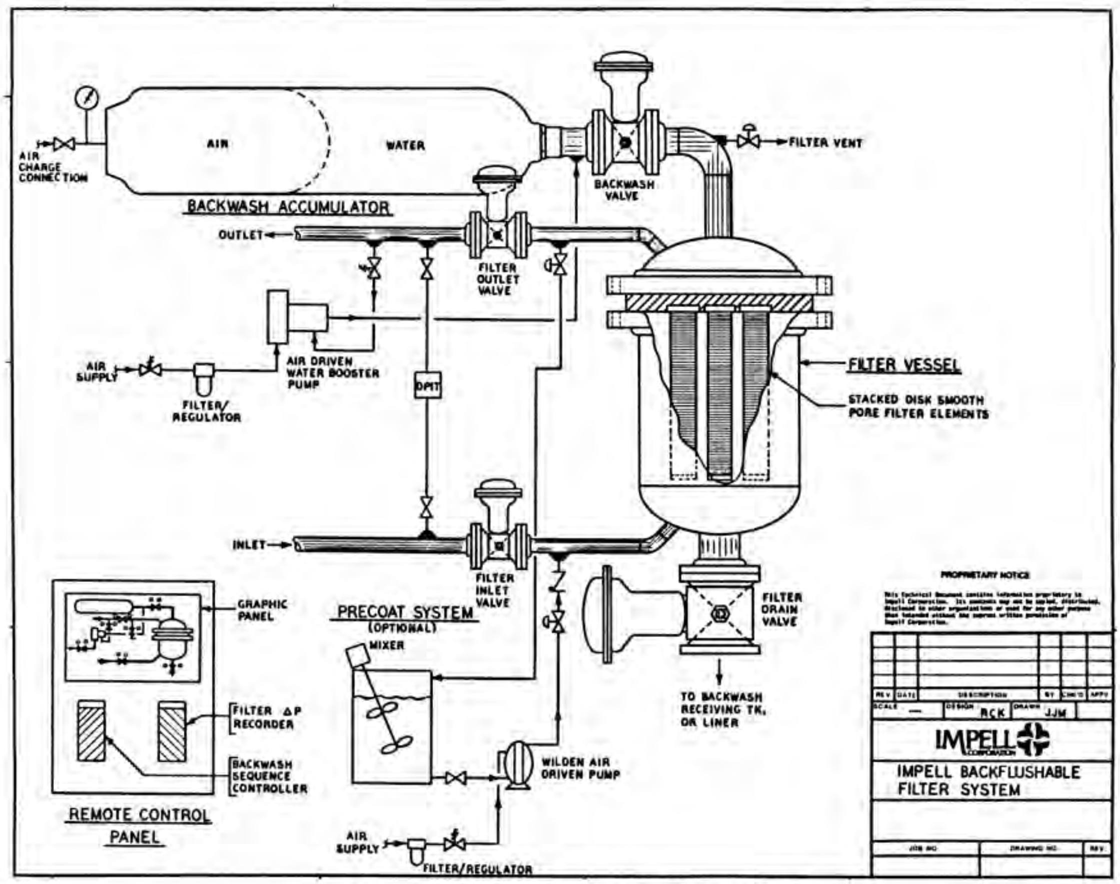

Fig. 1. Impell Backflushable Filter System

Test results show good filter performance and minimal Ecodex use. Continuous exposure of the filter to wastes for six months has not resulted in any change to the filter clean pressure drop or filter performance.

GENERAL DESCRIPTION, BACKFLUSHABLE FILTER SYSTEM

The Impell backflushable filter is a simple engineered system utilizing recently developed filter elements (ideally suited to optimize the use of new filter aid materials), a unique backflush concept, and a simple automated remote control system. The system is shown in Fig. 1.

Filter Elements - The filter elements are manufactured by Kamer Technology and were developed by Kamer and Impell specifically for use in dirty radioactive waste streams. The stacked disk smooth pore elements are made from corrosion resistant stainless steel or high nickel alloy.

The unique feature of these elements is the surface smoothness of both the exterior surface of the elements and the micron sized flow passages. These smooth surfaces prevent the accumulation of oil, other organic material, rust and very small particulates. The smooth uniform flow passages, along with the smooth exterior surface, allow the reverse flow of the backflush to remove any material which could impede the forward flow. Fig. 2 is a photograph of the three element assembly used for the Grand Gulf tests. Full size applications utilize up to 30 elements, 24 inches long within the filter vessel.

Fig. 2. Filter Elements

Backflush System - The function of the backflush system is to provide reverse flow through the filter elements to remove the dirt cake and carry it into a backflush receiving vessel. Along with the appropriate element design, the backflush system is the most important part of the entire system. The primary considerations for the filter backflush are as follows:

- The backflush fluid must flow uniformly throughout each flow passage in each element.
- The backflush fluid must have enough momentum to remove the particulate or crud from the flow passage inlets and the surface of the elements.

- The backflush fluid must be clean so it does not to plug the elements in the reverse direction.
- The backflush fluid should not cause a backflush receiving tank vent problem nor should the dirt be entrained in air during backflush.

The Impell approach for an optimum backflush system design is to use clean water, not air, to backflush the filter. The clean water can either come from the down stream side of the filter during operation or from an external clean water source. An air/water accumulator(s) is used with the air providing the driving force to expell the water at very high flow rates for very short times. The accumulator(s) is precharged with air to approximately 100 psig. The water is pumped into the water side of the accumulator by an air driven booster pump to a pressure of 250 to 300 psig. The flow rate through the filter in the reverse direction is approximately 50 times the forward flow rate.

Control System - As shown in Fig. 1, the dirty water flows into the bottom of the filter vessel, through the filter elements from the outside, up through the element clean side passages and through the element mounting plate to the filter outlet. The particulate in the water remains on the surface of the elements. As the dirt cake builds up on the elements, the pressure drop (dP) across the elements increases to a preset value (75 psid). At this point, the control system automatically backflushes the filter as follows:

1. The filter outlet and inlet valves close and the filter drain valve opens draining the dirty water and much of the dirt into the backflush receiving vessel.
2. A preset time (10-20 sec.) later, after the vessel has drained, the backwash valve opens for approx. 3 seconds. The high pressure water driven by the air pressure in the accumulators backflushes the filter.
3. The backwash valve closes, the filter drain valve closes and the filter vent valve opens.
4. The filter inlet valve opens refilling the filter and starting a timer for the vent valve.
5. When the vessel is full, the vent valve is closed and the filter outlet valve opens placing the filter back in service.
6. The booster pump starts and pumps clean water into the accumulators until a preset charge pressure (250 to 300 psig) is reached.

This sequence takes less than 1 minute to backflush the filter and approximately 5 minutes for the accumulators to recharge. When precoat is used, the control system also controls the precoat step automatically so that when dirty water is introduced into the filter the elements are already covered with a thin layer (approx. 1/32") of precoat material. The precoat material is measured and mixed with clean water in a precoat tank. A precoat pump circulates this water through the filter with the precoat accumulating on the elements and the water recirculated back to the precoat tank. If body feed is used during the filtration process the control system also controls the amount of body feed injected from the body feed mix tank based on increasing dP across the filter.

The control systems utilize state-of-the-art programmable controllers for the process control described above. In addition, many interlocks and permissives are programmed into the control logic to insure proper operation and to protect not only the filter but other related process equipment such as feed pumps, backwash tank levels, feed tank levels, etc.

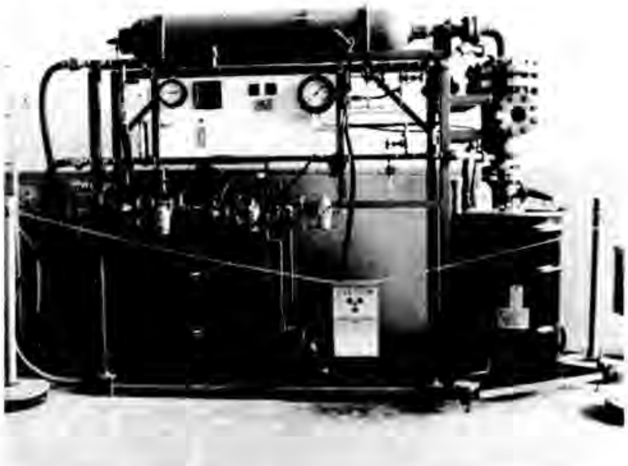

Fig. 3. Test System in place in the truck bay at the Grand Gulf Station.

TEST SYSTEM DESCRIPTION

Figure 3 is a photograph of the system in place in the truck bay at the Grand Gulf station. The test system used for the Grand Gulf tests is shown schematically in Fig. 4. Specific system specifications are as follows:

Filter Elements - Kamer smooth pore, stacked disk, 316 s.s.

Element Area - 2.06 $ft.^2$

System Flow Rates - 2 to 10 GPM (1 to 5 $GPM/ft.^2$ of element area)

Backflush - Clean water at 250 psig (nominal)

System Design Pressure - 150 psig.

Filter Vessel and Backflush System design pressure - 350 psig.

System Controls

All manual except backflush valve which is air operated with preset times to provide constant filter drain time and backflush time.

System Instrumentation

dP - 0-100 psig gauge inlet/outlet

- 0-100 psig transmitters inlet/outlet

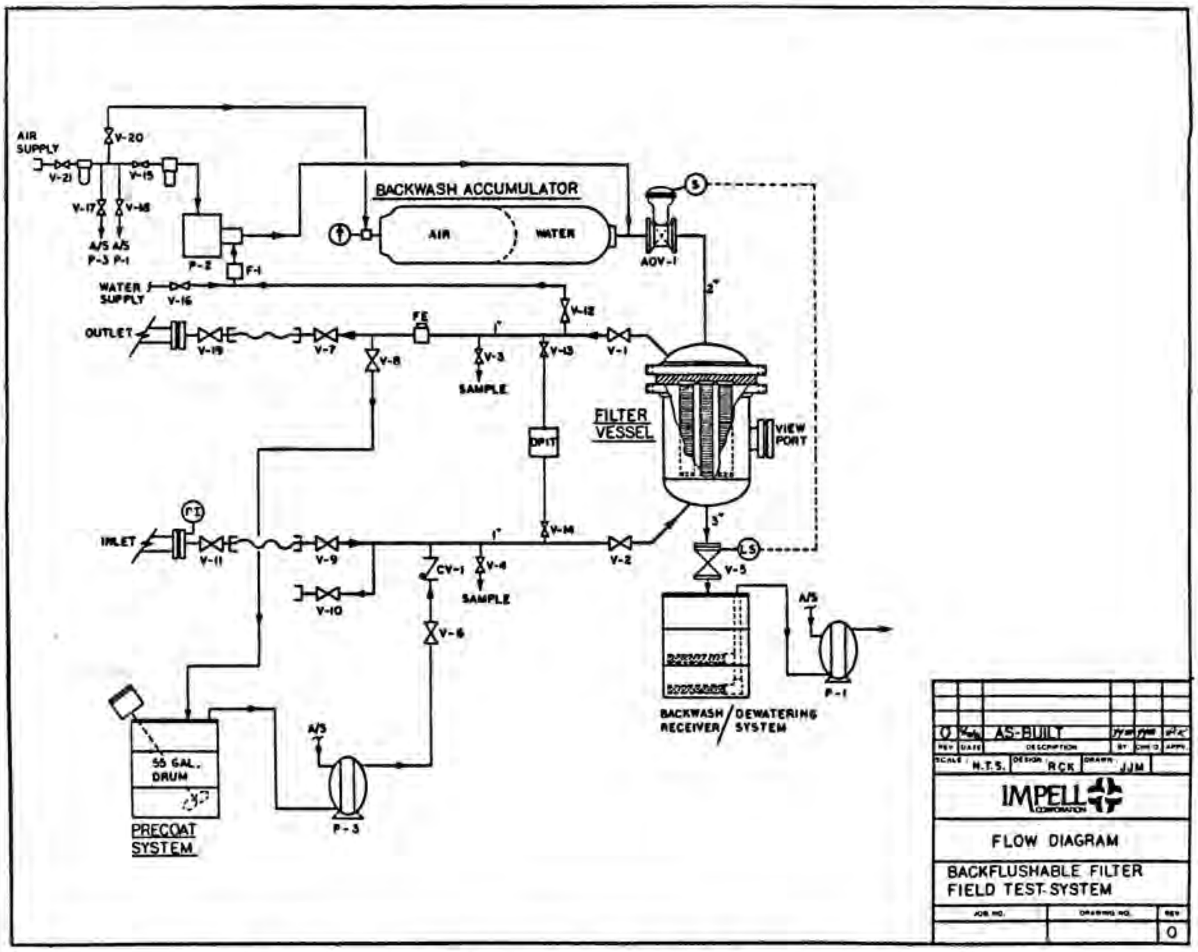

Fig. 4. Impell Backflushable Filter Field Test System Schematic

Flow - 0-18 GPM digital flow meter with totalizer - digital output to data acquisition system

Temperature - Ice bath compensated thermocouple

Accumulator press - 0 to 500 psig gauge

Samples - close coupled filter inlet and outlet sample valves

Required Services

Air - 80 to 100 psig utility air for AOV and air driven pumps - 10 SCFM max.

Clean Water - 2 GPM during accumulator recharging

Electrical - 120 V 60 Hertz for instrumentation and mixer

Data Acquisition

Manual - record dP, flow, samples

Micro Computer - records flow, total flow, temperature, dP. Samples taken manually.

TEST PROCEDURES

System Operating Procedures

Prior to system operation at Grand Gulf, complete procedures were prepared. These procedures cover the system operation and ALARA considerations.

Waste Stream Sample and Analysis Procedures

The most difficult part of the test program was determining a uniform method of taking samples which could be analyzed with current laboratory procedures. The total suspended solids (TSS) varied to such a degree that samples had to be handled differently and as such consistent results could not be obtained.

To get comparative TSS analysis, the sample size had to be small enough that all of the sample could be filtered through a 0.45 micron millipore pad (or equivalent pad). With the TSS being as high as it sometimes was, the sample size had to be limited to 100 ml.

The technique used to obtain the samples also had to be made very uniform. The sample valves are on the bottom of the inlet and outlet piping. The inlet sample valve tended to collect solids during normal operation. If the sample line and valve were not flushed immediately prior to filling the sample bottle, too many solids would be in the sample. To prevent this, the following procedure was used:

1. At 9 minutes into the test, using a 1 liter flush bottle, open sample valve wide open and flush 800 ml. into the 1 liter flush bottle. At exactly 1 minute after the start of the flush, take the 100 ml. sample opening the sample valve as far open as possible.

2. In the laboratory, pour the whole 100 ml. sample through a pre-dried and tared millipore pad. Rinse the bottle and filter funnel with demin water to wash any remaining solids onto the filter pad. Dry and weigh the millipore pad and calculate TSS.

3. Conductivity and pH were usually obtained from a larger sample normally taken from the collection tank after several hours of recirculation.

4. Some total organic carbon analyses were performed but usually the oil and grease contents were too high to use the laboratory TOC analyzer. To obtain oil and grease concentrations, a freon extraction procedure should be used. The scope of this test program did not allow for these analyses.

TEST CONDITIONS

Waste Streams Processed

The majority of the tests took feed from the floor drain collector tanks which had been placed on off standard recirculation for at least 2 hours prior to test initiation. Other tests were conducted with wastes from the waste surge tanks (primarily floor drains) and the equipment drain collector tanks. Specific test conditions are shown in Table I. In summary, test conditions were as follows:

Flow rate - 2 to 10 GPM (1 to 5 GPM/ft.^{2} element area)

Filter pressure drop - less than 1 psid clean
- up to 75 psid dirty

Feed stream conditions
- pH 7 to 8
- Conductivity - 15 to 200 micro mhos
- TSS - 10 to 2000 ppm
- Oil & Grease - up to 30 ppm
- Temperature - 80 to 120° F

Precoat & body feed - Ecodex 203H

FILTER PERFORMANCE

General

The filter was installed at the Grand Gulf Station on July 13, 1985. To date, 85 tests have been conducted over a wide range of variables. Table I shows the specific conditions for each test. As of December 1985 the filter still has the same clean dP as it did when it was installed and still has the same dirt holding capacity on similar waste streams. One of the major objectives of these tests was to demonstrate the long term ability to not show plugging tendencies both during operation and in wet lay up. This objective has been achieved.

The test system itself has performed with ease and has provided completely trouble free operation during the whole test period. The same backflush drum and dewatering elements have been used during the whole test program. This demonstrates the ability to dewater the filter sludge even with minimal Ecodex as part of the sludge.

Table I

Impell Backflushable Filter Test System
Grand Gulf Station Test Runs

RUN	PRECOAT	BODY FEED	TOTAL ECODEX	TOTAL ECODEX	FLOW RATE	TOTAL FLOW	TOTAL SUSPENDED SOLIDS	TOTAL DIRT	ECODEX /GALLONS		ECODEX /LB DIRT
	ML	ML	ML	LBS	GPM	GAL	PPM	LBS	ML/GAL	LBS/1K GAL	LB/LB
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Totals			[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			
Averages						[illegible]	[illegible]		[illegible]	[illegible]	[illegible]

Another factor worthy of comment is that significant amounts of oil have been in the waste streams processed by the test system. Although strictly qualitative, it appears that very little, if any, oil has broken through the filter cake and picked up down stream of the filter. The presence of oil or organics is further indicated by the fact that at the 80°F to 100°F temperatures in the truck bay, the oil and organics in the inlet feed and in the backwash tank have grown algae in significant quantities. This has left a black slimey layer especially in the backwash drum. The accompanying odor after backwashing verifies the biological activity taking place.

Specific Performance Parameters

- In all cases sampled, the outlet samples have shown less than 1 ppm TSS downstream of the filter.

- Average dirt captured by the filter for runs 28 thru 85 is 0.38 lbs. per run, i.e. clean dP to approx. 75 psid. 0.38 lbs./2.06 ft^2 of filter area = 0.184 lbs. dirt/$ft.^2$ of filter area per run.

- Dirt captured/lb. Ecodex - 0.5 to 10 lbs. dirt/lb. Ecodex

  Average, runs 28 through 85 - 3.25 lbs. dirt/lb. Ecodex

- Ecodex use/1000 gal. processed -

  Average, runs 28 through 85 - 0.43 lb. Ecodex/1000 gal.

  - 0.036 $ft.^3$/1000 gal.

Data Plots and Graphs

An Impell developed micro computer data acquisition system called PROCTOR, records data every minute. At the end of each test run the data is placed in a storage file where it can be utilized with Lotus 1-2-3 to generate curves and plot a wide variety of data. The raw data plotted for each test is dP versus total gallons processed through the filter. Several of these curves are included herein to show typical filter runs. Any other or all curves are available.

In an effort to understand the data and optimize Ecodex usage on floor drains, different plots were made to try and correlate several test variables.

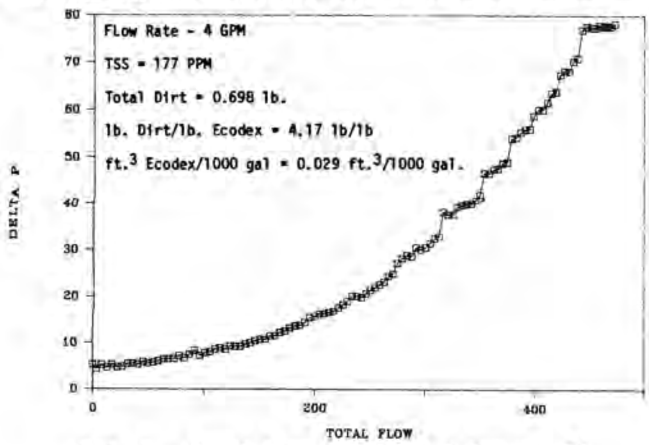

Fig. 5. Total Flow vs. delta P for Run 53

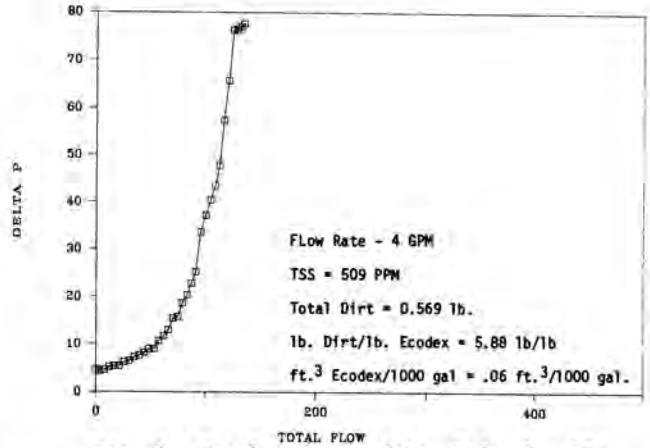

Fig. 6. Total Flow vs. delta P for Run 57

The following two plots show that the higher the TSS or total solids per run, the less Ecodex/lb. of dirt is required. The reason for this is twofold:

1. The solids in the high TSS tests are primarily large particles and/or resin beads. These particles tend to act like a filter aid material and therefore lessen the requirement for Ecodex.

2. The runs with greater than 10 ppm oil use up or blank the Ecodex at a much higher rate than the suspended solids alone. The runs on the right side of the plots had more than normal oil in the waste streams thus showing a higher Ecodex use than would be expected.

(Note - The numbers representing the data points are the run numbers.)

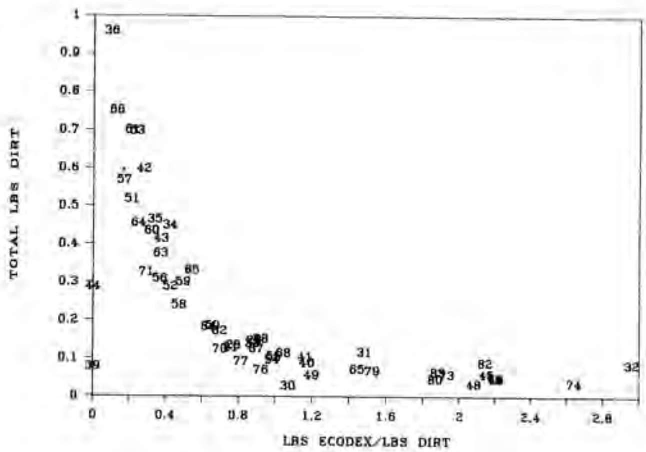

Fig. 7. Total lbs. of dirt vs. lbs. Ecodex/lbs. dirt for runs 27 thru 85 using 203H Ecodex

Figure 9 seems opposite to what would be expected. It seems that with more Ecodex or more Ecodex/1000 gal. the more water should flow through the filter. As in the previous two plots, however, the same situation with the oil applies, only it shows up on the opposite side of the plot.

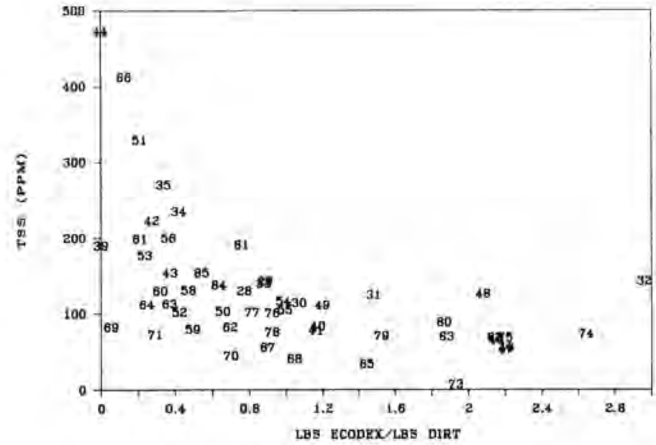

Fig. 8. TSS vs. lbs. Ecodex/lbs. dirt for runs 27 thru 85 using 203H Ecodex

The runs toward the right side of the plot had large particles and/or resin making up the TSS and were quite free of oil. Minimal Ecodex was required for large amounts of water.

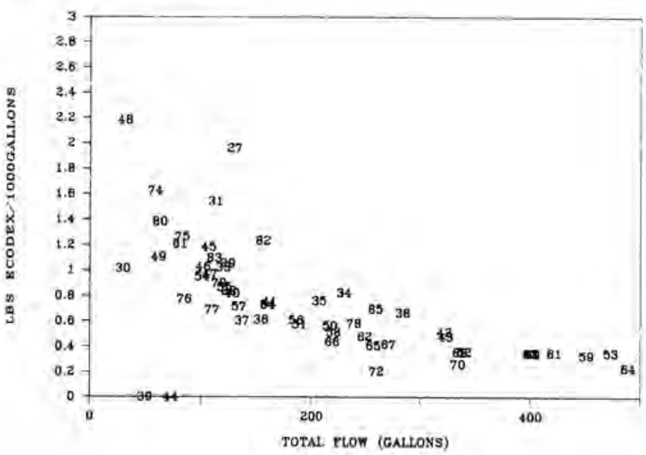

Fig. 9. lbs. Ecodex/1000 gal. vs. Total flow thru the filter for runs 27 thru 85 using 203H Ecodex

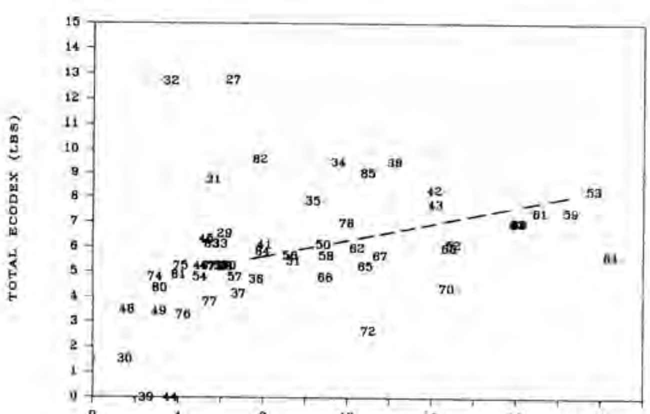

Fig. 10. Total Ecodex vs. total flow thru the filter scaled for a full size system

Figure 10 has been scaled up from the test system data to represent a full size system to process wastes at the Grand Gulf Station. This plot shows more of an expected trend in that the dotted line does show that with more Ecodex, more water can be processed. However, the slope of this line is very flat, which goes back to the same discussion on the previous plots with respect to oil and particle size distribution. It should be noted that for run No. 69 on equipment drains, the data point is 6.5 lbs. of Ecodex and 165,000 gallons of water.

SUMMARY

In all tests the Kamer stacked disk smooth pore elements provided adequate filtration performance, less than 1 ppm TSS in the filter effluent.

Ecodex use can be reduced from 0.67 ft^3 per 1000 gallons processed to 0.036 ft^3 per 1000 gallons processed. At a projected waste volume of 40,000 gallons per day or 14.6 million gallons per year this amounts to a volume reduction of 9,256 ft^3 of Ecodex per year. The associated cost savings are over 1.8 million dollars per year.

In addition, a full size system installed at the Grand Gulf Station would provide several operational and maintenance benefits including:

- The backflush time is reduced from 90 minutes to 10 minutes.
- The backflush water is reduced from 2000+ gallons to 400 gallons.
- System backflush, precoat, and body feed is completely automatic. The body feed is self adjusting based on filter pressure drop rise rate which is a function of waste stream dirt loading.
- System maintenance is minimized. Elements are permanent with very high mechanical integrity.
- Mixing of Ecodex requires only one tank for both precoat and body feed instead of the two tanks presently in use.
- The micro-computer based data acquisition and control room monitor system has 24 channel expansion with the capability of recording data, storing data, performing calculations, preparing reports, plots, and trends directly utilizing Lotus 1-2-3.