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Experiments on Cake Development in Crossflow Filtration for High Level Waste[1]

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ABSTRACT

Crossflow filtration is a key process step in many operating and planned waste treatment facilities to separate undissolved solids from supernatant slurries. This separation technology generally has the advantage of self-cleaning through the action of wall shear stress created by the flow of waste slurry through the filter tubes. However, the ability of filter wall self-cleaning depends on the slurry being filtered. Many of the alkaline radioactive wastes are extremely challenging to filtration; e.g., those containing compounds of aluminum and iron having particles whose particle size and morphology reduce cake permeability.

Low filter flux can be a bottleneck in waste processing facilities such as the Salt Waste Processing Facility at the Savannah River Site and the Waste Treatment Plant at the Hanford Site. To date, increased rates are generally realized by either increasing the crossflow filter axial flowrate, limited by pump capacity, or by increasing filter surface area limited by space and increasing the required pump load.

The Savannah River National Laboratory (SRNL) set up both dead-end and crossflow filter tests to better understand filter performance based on filter media structure, flow conditions, and filter cleaning. Using non-radioactive simulated wastes, both chemically and physically similar to the actual radioactive wastes, the authors performed several tests to demonstrate increases in filter performance. With the proper use of filter flow conditions, filter flow rates can be increased over rates currently realized today.

This paper describes the selection of a challenging simulated waste and crossflow filter tests to demonstrate how performance can be improved by varied filter operation methods. Those methods were a slow startup to better develop the filter cake and scouring the filter wall. The results showed that for salt waste and metal oxide hydroxide sludges the process of backpulsing is not necessary to maintain a good filter flux and the process of periodically scouring the filter improves filter performance. The results also imply initial filter operation is important to develop a filter cake that minimized pressure drop, the presence of a filter cake can lead to improved solids separation, and a well-

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developed cake with periodic scouring may allow a good filter flux to be maintained for long periods of time.

Keywords: Radioactive Sludge, Non-Newtonian, Filter Cake, Filtration

Introduction

Crossflow filtration is a well-established technology, but the method of use and the efficiency of its separation vary widely for each different industrial application and indeed within production-end product categories. Figure 1 is a diagram of a typical crossflow filter arrangement, shown in a horizontal orientation but could be vertical or at some other inclination. The arrows in the center, parallel to the walls, represent the slurry flow or the axial velocity (AV) of the slurry. Each of the walls is the porous filter medium that separates permeate from the slurry. The arrow, perpendicular and outside the top wall, represents the permeate. The motive force that drives the liquid through the filter wall is the difference in pressure from the slurry to the permeate and is referred to as the transmembrane pressure (TMP).

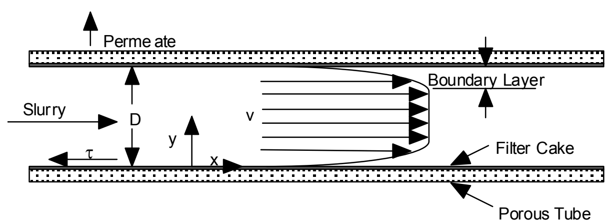

Fig. 1 Typical crossflow filter arrangement

For the United States Department of Energy (DOE) Complex, stored radioactive wastes are being prepared for long-term storage and disposal with many technologies. Treatment of much of that waste begins with the separation of suspended solids from the liquid by filtration, including crossflow filtration. Those wastes can be very challenging to filters causing a bottleneck for an entire processing cycle. A better understanding of crossflow filtration with such wastes may help to increase filter performance and thus overall waste treatment throughput.

The range of wastes to be treated is large [1], but in general they usually have high soluble ionic salt contents and are radioactive. Due to the risk/costs of radioactivity, testing was done with a non-radioactive simulant; however, actual waste testing will be necessary in the future. The selected simulant was made in a manner that the chemical and physical properties were typical of the actual waste. Choosing a waste that would be difficult to filter was important. The waste should contain components that make filtration difficult [2]; e.g., iron and aluminum oxides, small particle size, and some past history of filtration so a comparison could be made. The candidate selected a salt waste, referred to as Sludge Batch 6 (SB6) for which the properties will be discussed later, but the selection was considered very challenging with respect to the compounds it contained and the large range of particle sizes.

When dealing with micro or ultra-filtration, one operational issue that has often been considered is how to maintain a filter surface with minimal cake. The rationale is that a cake-free surface will allow the solid-liquid separation to occur faster because the only pressure drop through the filter wall would be due to the filter membrane itself [3]. For crossflow filtration to minimize cake buildup, the predominant method is backpulsing, which is the reversal of permeate flow through the filter membrane for very short periods to help remove cake from a filter surface. In many cases backpulsing is absolutely necessary to maintain a high permeate flux, like in the water treatment industry [4]. Some backpulsing frequencies can be quite high; for instance, it could exceed 1 Hz as used by some in the biochemical industry [5] where the backpulse duration is only fractions of a second. Some researchers [6] state that "one method of reducing membrane fouling is rapid backpulsing," and "can provide in situ cleaning by removing some of the foulants from the membrane surface or pores." Up to a 30-fold increase with the use of backpulsing over no backpulsing has been realized.

At issue is an ongoing need to keep the filter surface clean; i.e., minimizes filter cake. Is this the approach method for all slurries? When waste processing plants were designed to treat stored salt wastes at the Hanford and Savannah River Sites, backpulsing was included to help maintain filter fluxes high. Unfortunately during the last ten years or so, filter tests have shown that backpulsing has not been very effective [7-9]. While much time and effort were invested to design robust flow-reversing systems, results have not been promising.

Along with backpulsing another method to minimize cake buildup is to flow the slurry very fast past the filter surface so that the shear stress would strip the cake from the wall. However, typical axial flowrates used in operation; e.g., 3-5 m/s, may not suffice for some suspensions that are viscous or have a strong affinity for the filtration surface. To address this need, a concept of a rotary microfilter [10] was developed that spins the filtration surface at a rate such that the filter outer surface moves at more than 18 m/s. In fact, approximately 70% of the filtration surface is kept completely free of cake.

Another attempt to prevent cake to build on the filter surface is never letting the cake settle by reversing the slurry flow every couple of minutes [11], but it takes considerable energy for large systems to reverse flow. Indeed, having a clean filtration surface does lead to high filtration fluxes initially; however, when the surface is clean, it is always exposed to the smallest particles in a slurry. Specifically for backpulsing it has been shown that once a cake is lifted off a filter surface, the smallest particles are the first to return to the surface, which accelerates depth fouling [12-13]. Because of this fact backpulsing was recommended to be kept at a minimum [7].

Cake Development. Because of poor filter performances and the ineffectiveness of backpulsing with stored salt wastes [2, 7], tests were developed to filter without backpulsing. Furthermore, filtration began by trying to establish a cake that would be more permeable and thus lead to better filter fluxes. Of course, the filter membrane is itself a filter, but by forming a filter cake on the surface, a secondary filter is established [14]. When forming a cake, it is always important to take into account the nature of the slurries and sludges being filtered [15]. From past work [7] it appeared that the solids adhered well to the filter surface based on the loss of the backpulse effectiveness in a very short time (hours), a time brief enough that filter depth fouling was probably unlikely. Unfortunately, no direct evidence of surface adhesion or fast depth fouling exists; therefore, an assumption of good adhesion led to the method of cake development used in this study. In the past, the procedure to start and maintain filtration was to fill the filtration and slurry systems, start filtration with an immediate backpulse, then periodically backpulse when the permeate flux became unacceptably low [7-9]. Depending on the waste stream, the effectiveness of backpulsing drops with time. Eventually filtration has to be stopped to chemically clean the filter membrane to remove the depth fouling.

The intention of the present study was to not avoid cake buildup but to actively establish a cake, probably more complex than those that develop on dead-end filters [16]. Hopefully, the cake would be permeable and act to filter even smaller particles than what the filter membrane could. If the filter could be started in a fashion so the smallest particles in the cake would not be near of the filter surface, Fig. 2(a), but actually closer to the top of the cake, Fig. 2(b), this may help, especially if that top layer could be periodically stripped off. In fact, research has been performed [17] that clearly shows the orientation of cake particles can be affected by properly controlling the transmembrane pressure on start-up and SRNL wanted to take advantage of this point.

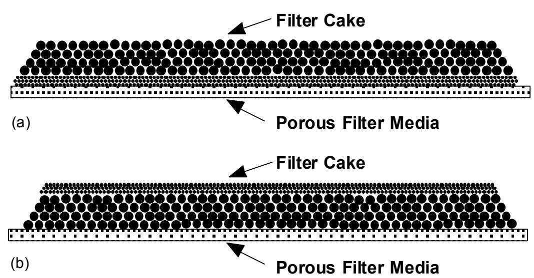

Fig. 2 Schematic of cake on filter surface with most of the smallest particle in the cake at the (a) bottom and (b) top

To further create and maintain a permeable cake, a mechanism of what will be called "scouring" was tried. This is an action of stripping off some of the established cake to remove the smallest particles by increasing the slurry axial velocity for a short period while no filtration is occurring.

Scouring. During the test, many trials were conducted to check if permeate flux could be improved while avoiding filter cleaning. A method that the authors termed scouring seemed to work the best. The scouring process begins while the filter is in steady state; i.e., the slurry axial velocity is constant and the filter cake is well- established. The permeate flux is then stopped for a short period. This has been tried by others [18]; however, an extra step was added to increase the axial velocity by 50 to 80% above the operational velocity. After being held at this higher velocity for 15 to 20 minutes, the velocity is then returned to the original value while permeate flow is reestablished very slowly over a 15-minute period. The expectation was that scouring would remove the upper layer of cake that could contain small particles [17] and leave a base filter cake free of the smallest particles. The hope was to return the filter rate to what was initially established at start-up. If successful, the further hope was this process could be repeated indefinitely.

Currently, two large treatment plants are under construction that include crossflow filtration, the Waste Treatment Plant at the DOE Hanford Site and the Salt Waste Processing Facility at DOE Savannah River Site. For the former, the crossflow filters are 0.0127-m (1/2–inch) inside diameter stainless steel tubes and for the latter, 0.0095-m (3/8-inch) inside diameter stainless steel tubes. This paper discusses research carried out to demonstrate the differing performances between these filters. Both of these filters are made with a 0.1 micron nominal pore rating and of a symmetric sintered metal design. Because the only difference between these two filters is geometry, another tube design was added for comparison. This third tube has an asymmetric design, a 0.0095-m (3/8-inch) inside diameter, and a 0.1 micron absolute pore rating. While this last tube is still made primarily of sintered stainless steel, the inner tube surface is coated with a 10-micron thick layer of zirconia. To elicit a side-by-side performance of all three filter tubes, they were placed in parallel in a test facility so the same test simulant would flow through each at the same time. Because the properties of wastes to be treated can change with time, removing the issue of aging is important for it could confound results.

EXPERIMENTAL SETUP

Crossflow Filter Equipment. Figure 3, a schematic of the test rig, was made up of three basic flow loops:

1. Slurry loop – contains three 0.6-m long filters and their housings, which serve as the primary flow path for circulating slurry. This "loop" was actually made of three loops to control the filters separately to maintain the same flow conditions in each despite their geometric differences.
2. Permeate loop – begins at the filter housing and allows the separated permeate liquid from each filter to flow to a common header and back to the slurry tank.
3. Cleaning loop – allows the three filters to be cleaned without removing most of the test slurry that remained in the lower portion of the test rig during cleaning.

To circulate slurries in the test rig, two 10 hp Galigher centrifugal pumps were used. The impeller and impeller housing were lined with EPDM to be compatible with both the $pH > 14$ slurry that was tested and the $pH < 1$ acid cleaning solutions. The two pumps were used in series for the slurry loop to attain a head of greater than 450 kPa at 225 lpm.

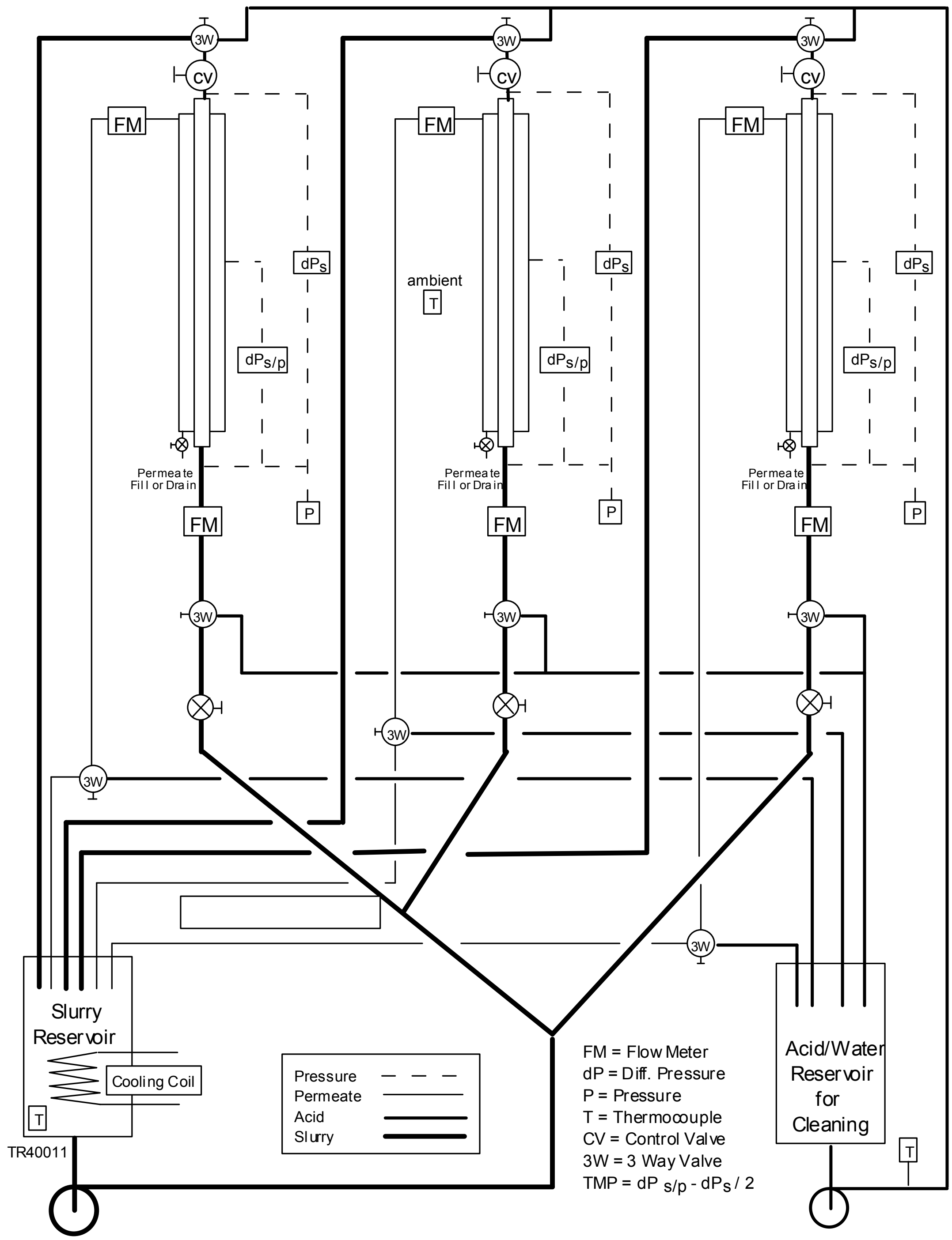

Fig. 3 Schematic of the crossflow ultrafiltration test facility

Crossflow Filters. Details for the three crossflow filters tested are in Table 1. Figure 4 shows one end view of the three filter tubes after they were machined to fit in the filter housing. Note the filter wall of the Mott tubes, a symmetric design, is thicker than the Pall filter, an asymmetric design with an inner coating of zirconia. A symmetric design means the porous wall is made of the same material and the pore rating is the same throughout. An asymmetric design means the porous wall is made of two or more layers of material, which can be the same or different. The pore rating for each layer is generally different, with the surface in contact with the material to be filtered containing the smaller pore rating.

Table 1 Filter Tubes Specifics

Filter[a]	Actual Inside Diameter (m)	1 x Standard Deviation (m)	Actual Outside Diameter (m)	Medium Design[b]	Primary Material	Active Length (m)	Filter Surface Pore Rating[d]
Mott	0.01237	6.62E-05	0.01658	Symmetric	316L Stainless	0.572	0.1 micron nominal
Mott	0.00923	6.91E-05	0.01301	Symmetric	316L Stainless	0.572	0.1 micron nominal
Pall	0.00994	8.32E-05	0.01218	Asymmetric[c]	316L Stainless	0.572	0.1 micron absolute

(a) Mott refers to the Mott Corporation and Pall refers to the Pall Corporation.
(b) Symmetric = A filter that has the same material and pore rating throughout. Asymmetric = A filter that has two or more materials and pore ratings.
(c) Pall filter consists of a 10-micron thick inner surface made of zirconia and a stainless steel substrate with a much larger pore rating.
(d) The word "nominal" for a filter rating is a vague term because its meaning is manufacturer dependent. Further, a "nominal" rating does not give an exact size to a filter medium, but rather an approximation to the expected performance of a filter. In the case of Mott, a nominal rated 0.1-micron filter means approximately 95% of particles greater than 0.1 micron will not pass the filter. For the 0.1 micron absolute rate 100% of particles greater than 0.1 micron will not pass through the filter. A rough approximation between the two ratings is a 0.1 micron nominal which has been equated to at 0.8 micron absolute rating [19].

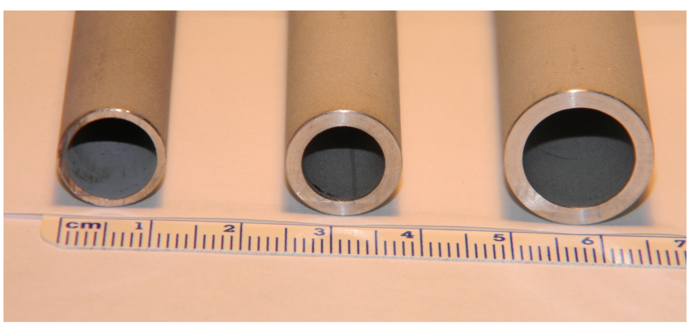

Fig. 4 Three filter tubes studied, left to right: 0.0095-m PALL, 0.0095-m MOTT, and 0.0127-m MOTT

Once installed in the test facility, all three tubes had an active filter length of 0.57 m (Fig. 5). A close-up of one of the tubes is shown in Fig. 6.

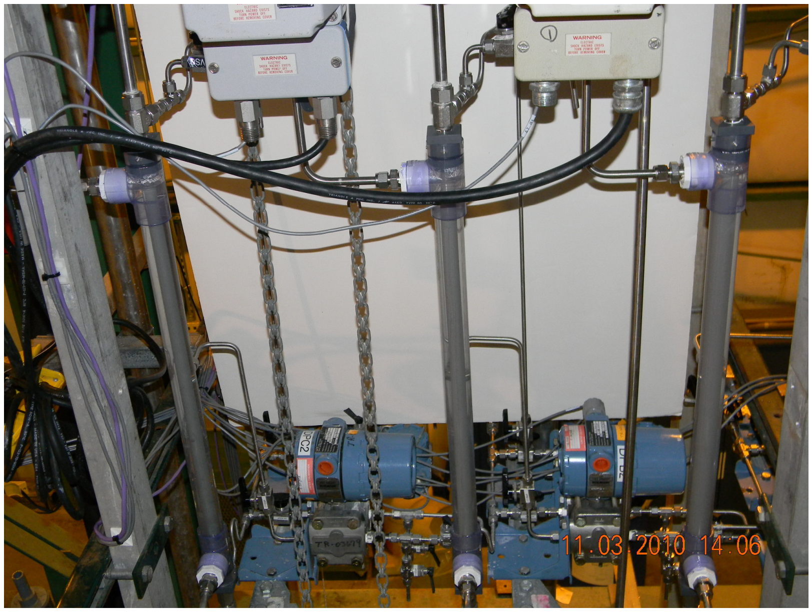

Fig. 5 Three filter tubes in filter housings

Fig. 6 Close-up of one of the three tubes

Instrumentation. The measurement equipment used for this experiment is shown in Table 2.

Table 2 Measurement Equipment

Quantity	Device	Type	Manufacturer	Of Reading Accuracy*
5	Thermocouple	E	Omega	0.6 to 1.1°C
6	Pressure Transducer	Differential	Rosemount	0.14 to 0.83 kPa
3	Pressure Transducer	Gauge	Rosemount	0.28 to 0.41 kPa
3	Flow Meter	Magnetic	Fischer-Porter	1.89 to 6.06 E-6 m^3
3	Flow Meter	Magnetic	Fischer-Porter	1.14 to 2.27 E-4 m^3
1	Turbidity	Benchtop	Cole Parmer	Greater of ±2% Reading or 0.01 NTU

* Note: Accuracies are a function of the instrument and calibration. The uncertainty introduced through the use of the 16-bit data acquisition system was insignificant (<0.1% reading) and was not included in the values above.

Measurement Uncertainty. The measurement uncertainties (95% confidence level) for the important calculated quantities are as follows:

Slurry Velocity in a Filter Tube: ± 9 %
Transmembrane Pressure: ± 1 %
Permeate Flux: ± 12 %

These uncertainties are based on the Law of Propagation of Errors.

Simulated Waste Slurry. Two waste simulants were obtained for this test, a HM Waste Simulant – Sludge Batch 6 (SB6) and a Purex Waste Simulant – SRS Tank 8F[3].

In a separate dead-end filter test, using laboratory cup filters, the SB6 was found to filter significantly slower than the Tank 8F waste. Therefore, SB6 was chosen for the crossflow filter test and the properties of the SB6 sludge properties are in Figs. 7-9 and Tables 3 and 4. The yield stress of 54.6 Pa for SB6 simulant is equivalent to waste tanks with the highest yield stresses and therefore should be conservative in this aspect.

The size of particles for the SB6 simulant had a large variation from 0.3 to 300 microns, which captured well the ranges expected in the actual wastes [20]. In fact, particle size distribution was tri-modal (Fig. 7) with peaks at approximately 0.8, 8, and 50 microns. This range was assumed to be very challenging to the filters. Finally, note that the SB6 was mixed with a 5.6 M sodium supernatant to obtain a 5 wt% solids loading before testing.

[3] Nuclear Waste Definitions: An HM Waste refers to a liquid waste that came from the H-Canyon (at SRS) Modified Purex process and a Purex Waste resulted from the **P**lutonium **UR**anium **EX**traction process.

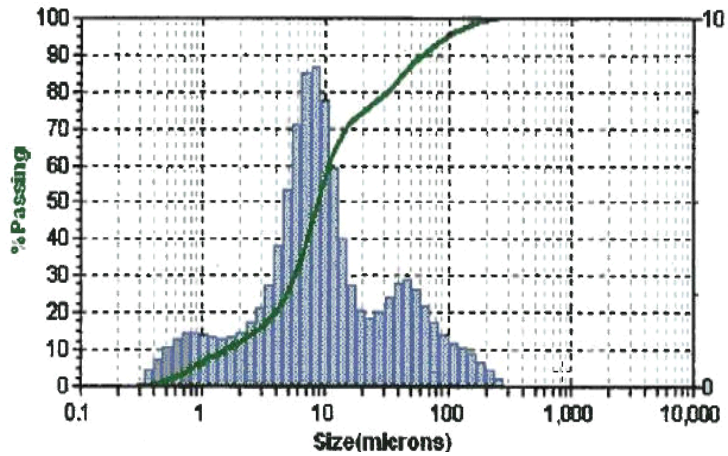

Fig. 7 Particle size distribution of sludge simulant

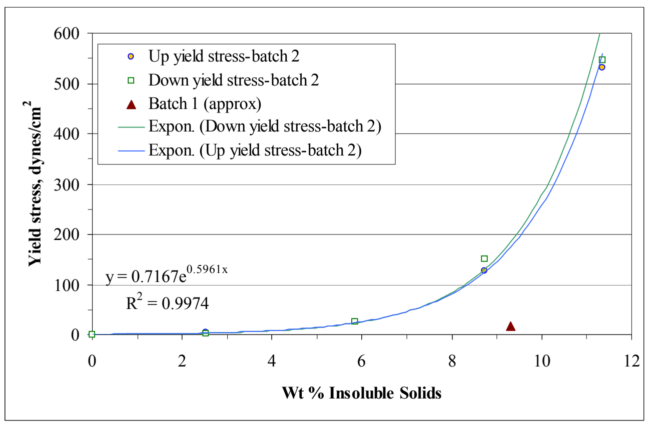

Fig. 8 Sludge Batch 6 was used for the test. (Note: 10 dyne/cm^2 = 1 Pa)

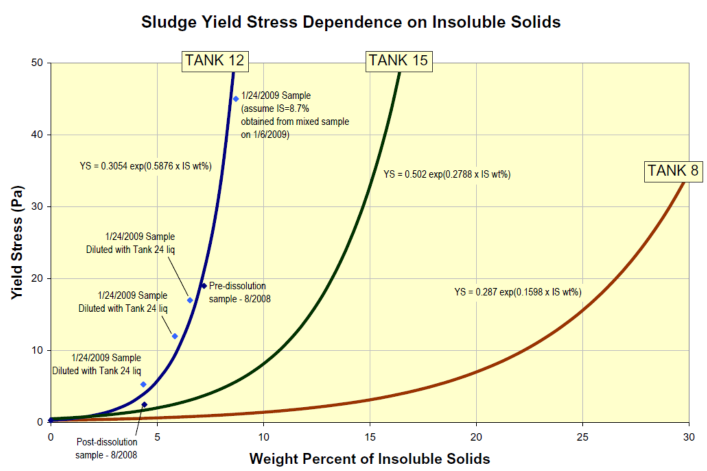

Fig. 9 Range of yield stress for wastes stored in SRS tanks

Table 3 SB6 Sludge Constituents

Component	Calcined Solids, wt%	
	Target	***Actual***
Al	16.181	15.80
Ca	1.147	1.08
Ce	0.085	0.08
Cu	0.085	0.10
Fe	17.743	18.02
K	0.021	0.24
La	0.074	0.08
Mg	0.552	0.55
Mn	5.982	6.31
Na	19.305	17.77
Ni	2.231	2.30
S	0.712	0.28
Si	1.232	1.52
Zn	0.053	0.06
Zr	0.234	0.22
Sum	**66.0**	**64.4**

Table 4 Properties of SB6

	Target	***Actual***
Slurry density, g/mL	1.12 ± 0.05	1.12
Total solids, wt%	18.2 ± 2%	16.7
Insoluble solids, wt%	14.0 ± 1%	10.4
Anions, mg/Kg		
Nitrite	8807 ± 10%	1110
Nitrate	6096 ± 10%	6470
Phospate	27 ± 25%	<100
Sulfate	904 ± 25%	1060

Notes for Table 4:
Simulant properties “as-received”:
Bingham Yield Stress = 54.6 Pa
Bingham Consistency = 17.8 cP

DISCUSSION

Cake Development, Long-Term Slurry Flux at 5 wt% of Undissolved Solids, and Scouring. The overall test results are in Fig. 10, which documents the raw data over 12 days of continuous filter operation where time interval was 15 minutes between set conditions and 10 seconds during condition changes.

The three filters were preconditioned by previously subjecting them to the test slurry, followed by a pre-acid water rinsing, an acid cleaning, and a post-acid water rinsing. This was performed until the water fluxes returned to those obtained before filtering with slurry. The preconditioning was an attempt to put the filters in a "used" condition to avoid the anomaly of new filter performance.

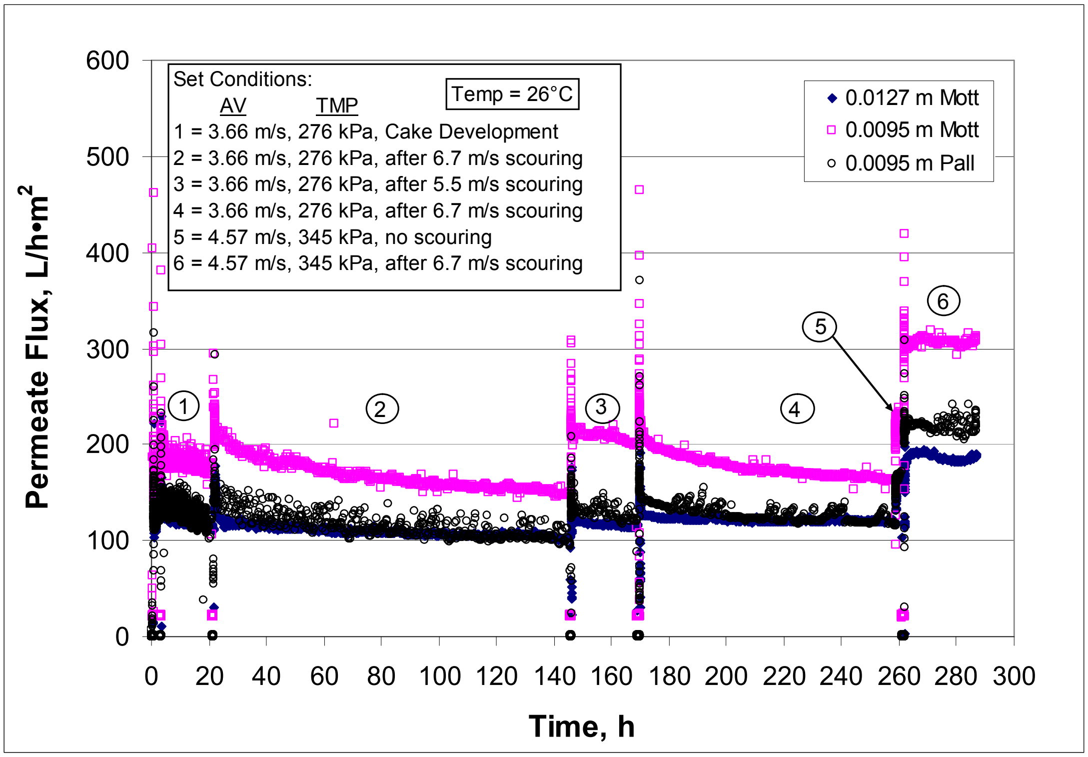

Fig. 10 Long-term 12-day filtration test done at the conditions listed in the legend and with the slurry at 5 wt% solids loading with a constant temperature of 25°C±2°C

Region 1: Cake Development and Scouring. The filter system was very slowly filled with the test slurry while the permeate system was shut so the filters would not become challenged prematurely. However, the permeate system did slowly fill with permeate as liquid separated from the slurry into the filter housing. This was possible because the air in the permeate housing was drawn into the slurry through the filter, which then percolated through the slurry loop until it was released to the atmosphere from the slurry reservoir. Once the slurry was circulating at a very slow rate; i.e., the axial filter velocity was less than 0.5 m/s, and air stopped leaving the system, then the permeate system was allowed to flow. The permeate flow was established slowly over a 15-minute period. Once both the permeate and slurry loops were filled, the permeate flow was once again stopped. At this point, the flow conditions for filtration were established; i.e., axial velocity (AV) = 3.66 m/s and a transmembrane pressure (TMP) = 276 kPa. (These conditions were chosen because they had been selected from previous work [7] as the best for filtration.) The permeate flow was then very slowly (15 minutes) engaged. With the permeate flow established, the system was allowed to run about two hours to allow the filter cake to develop, as noticed by a slight drop in filter rate. After that period the filters received the initial "scouring" for 15 to 20 minutes.

Scouring, previously explained in the Introduction, conducted after two hours, is hard to observe in Fig. 10 but it is exactly what was done between Region 1 and Region 2. In fact, it is what was done between Regions 2 and 3, 3 and 4, and 5 and 6, as noted by the jump in permeate flux. That is, at no time were the filters cleaned or backpulsed but only scoured. After each scouring, the filtration flux return to approximately the same value, implying that no significant depth fouling had occurred. Over the entire 290 hours (12 days) of continuous filtration, the filters were never backpulsed or cleaned, and, after each scouring, the filter flux always returned to its initial value at the start of the specific region.

Region 2: Long-Term Filtration. By focusing on Region 2 of Fig. 10, the better performance of the 0.0095-m Mott filter over the 0.0127-m Mott and the 0.0095-m Pall is seen. An interesting feature is the higher flux of the smaller diameter filter tube. The 30 to 40% higher flux of the small Mott tube over the larger Mott tube was not a surprise as this has been studied previously [21], but it was never observed with the same slurry at the same time; this evidence was reassuring. The improved filter flux is directly related to the higher wall shear for the smaller of the two tubes with the same porosity. This improvement is on the order of ratio filter surface areas (or diameters because the filter lengths are the same); i.e., 0.0127/0.0095 = 1.34.

The other interesting aspect seen in Region 2 is the very slow rate of decline in the filter flux. The drop in flux is approximately 30% over five days, a significant improvement to the 80% drops experienced from past works [7, 9].

Finally, the large difference in flux between the two tubes with the same insider diameter of 0.0095 m must be related to the different pore structure. The Mott filter is listed as a 0.1 micron nominal pore and the Pall is a 0.1 micron absolute pore. As mentioned earlier, the 0.1-m Mott has been estimated [22] to be an approximately 0.8 micron absolute pore rating; therefore, the Pall had a much tighter pore structure. The smaller pores do a much better job to separate the smallest solid particles but also results in a lower flux because of a much higher base membrane flow resistance. The question then becomes: Is the much tighter pore needed for these type wastes? One way to determine this would be to measure the turbidity of the permeate. Unfortunately, the turbidity of the permeate of each filter could not be measured because all three streams were joined in a common header, as the permeate was returned to the slurry reservoir. However, the turbidity of the joined stream was measured and that would tell at least the separation efficiency for the tube with the largest pore openings:

Turbidity (±0.01 NTU)	
Deionized water only:	0.26 NTU
From filters using only water:	0.25 NTU
From filter using 5 wt% SB6:	0.03 NTU

These data imply that not only does the filter cake act as a secondary filter but it prevents even the smallest particles from passing through the filter. This means that the more open pore structure is more efficient. Of course, the pore size cannot be allowed to become too large because eventually depth fouling would confound operation.

Region 3, 5, and 6: Higher Flow Conditions. Figure 11 is an excerpt of Regions 3 and 6 from Fig. 10 of only the 0.0095-m Mott data. Because of the success of a much higher and longer sustained filter flow rate than expected, it was of interest to examine if higher flow conditions would result an even higher permeate flux. After several scourings and a return to the same AV and TMP, those values were increased.

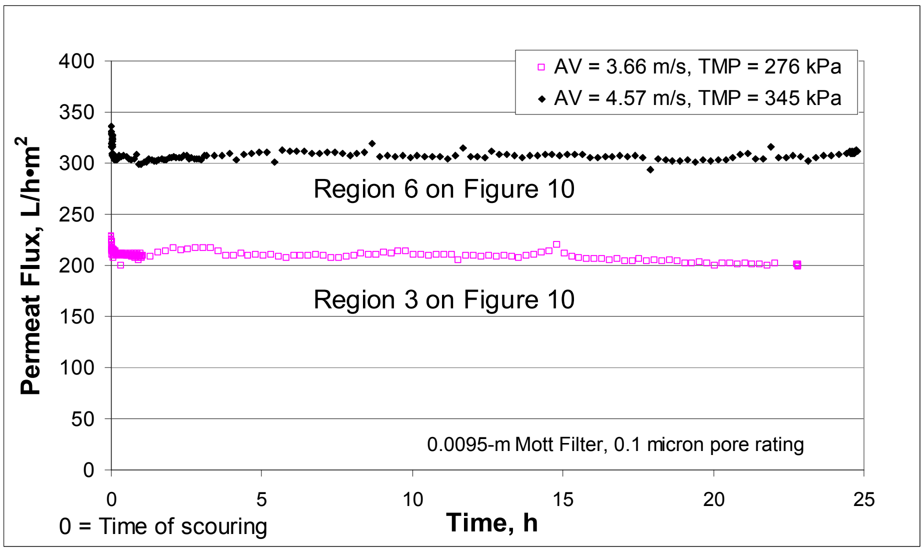

Fig. 11 Filter performance at a single set of flow conditions at 5 wt% solids loading

At the end of a successful long term run, shown as Region 4 in Fig. 10, the flow conditions were increased to an AV of 4.57 m/s and a TMP of 345 kPa, without scouring. Indeed the filter fluxes increased by about 50%, but this is only about 15% of the starting flux of Region 4. However, after a scouring was done and then a return to the conditions of 4.57 m/s and 345 kPa, the increase was 100% or about 43% above the starting point of Region 4.

This 43% can be seen better in Fig. 11 which illustrates the 20+ hours of operation after a scouring that started Regions 3 and 6 with the 0.0095-m Mott filter. The permeate flux at an AV of 4.57 m/s and a TMP of 345 kPa was surprisingly high. It exceeded 300 L/h•m^2 and remained high for a full 24 hours. With continual scouring this flux may be maintained for a very long time.

Comparison to Other Crossflow Filters and Waste Types. Data to directly compare the results to those using the same filters and slurry simulant operating in the traditional method do not exist. The traditional method entails (1) a fast start-up of slurry and permeate flow with the full TMP, (2) an initial single backpulse to clean the filter surface, followed by (3) periodic backpulses, as the permeate flux drops to a predetermined value. These data were not obtained during this test, but a large database exists [23-24] with similar waste streams and filters that demonstrate past and current operation. Those data roughly show that with the traditional method the permeate flux begins at approximately 200 L/h•m^2, but within 12 to 36 hours the flux drops to below 50 L/h•m^2, which requires filtration to stop so the filters can be cleaned with acid. The scouring method described in this paper apparently resulted in much better filter performance.

Indirectly, a comparison can be made that implies the current results are certainly a significant improvement in filter performance. A significant database exists with another SRS waste previously mentioned; i.e., Purex waste. This type waste was shown in Fig. 9 as Tank 8 waste, which has significantly less yield stress that the HM waste tested in this research, SB6. The SB6 waste is similar to those of Tanks 12 and 15, also shown in Fig. 9. As was stated earlier, to confirm that the SB6 waste would be more difficult to filter, a dead-end test was performed with the results shown in Fig. 12. The filter medium was of 0.45-micron nylon, and the slurries were filtered simultaneously using the common vacuum source so that the applied TMP would the same. Slurries of both type wastes were made at two different solids concentrations, 0.1 wt% and 5 wt%. At both concentrations the SB6 filtering flux was less than half that of the Purex type waste.

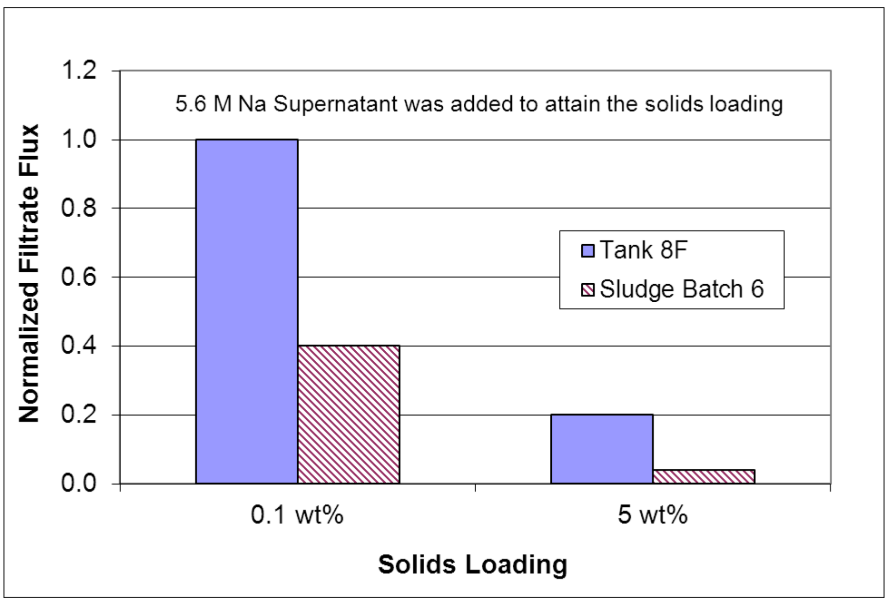

Fig. 12 Comparison of a the filterability of a Purex-type waste (Tank 8F) to an HM-type waste (SB6) in a dead-end filter normalized by the fastest filter flux

The yield stress of the HM-type wastes; e.g., SB6, is significantly higher than Purex-type wastes; e.g., Tank 8F, but, besides this fact, the HM wastes contain significantly more aluminum [25-27], which increases viscosity and are harder to filter. With this information, any crossflow filter data using Tank 8F waste is expected to be significantly easier to filter than SB6 waste.

A previous study [19] was performed with Tank 8F waste to compare six different filter media to determine which would filter the fastest. One of those filters was the same type as one used in this study; i.e., a Mott 0.1 micron stainless steel filter with a 0.0095 cm inside diameter. Unfortunately, that study only compared the filter fluxes at a single point in time; i.e., after 30 minutes of filtering at 25°C, and at one flow condition, after which the filtering was restarted at another condition. That process was repeated for 11 combinations of AV and TMP. The AV ranged from 1.2 m/s to 4.3 m/s and the TMP ranged from 103 kPa to 310 kPa. The averaged flux for 11 tests, with a solids concentration of 4.5 wt%, was 80 L/h•m^2 [19]. The result from this work at 30 minutes (see Figs. 10 and 11) with a solids concentration of 5.0 wt% was 208 L/h•m^2 ±25 L/h•m^2 (AV=3.7 m/s, TMP = 276 kPa, T = 25°C) and 300 L/h•m^2 ±36 L/h•m^2 (AV=4.6 m/s, TMP = 345 kPa, T = 25°C). For both cases the filter fluxes, when using a more challenging slurry to filter, were significantly better, implying by carefully handling the filter cake a superior performance is possible.

CONCLUSIONS

Experiments that use non-radioactive simulants for actual waste always carry the inherent risk of not eliciting prototypic results; however, they will assist in focusing the scope needed to minimize radioactive testing and thus maximize safety. To that end this investigation determined that:

(1) Backpulsing is not necessary to maintain a good filter flux with salt wastes and metal oxide/hydroxide sludges.
(2) Scouring a filter without cleaning will lead to improved filter performance.

The results also imply:

(3) Filter cake is something that should be properly developed in initial filter operation.
(4) The presence of a filter cake can improve the solids separation by an order of magnitude as determined by turbidity.
(5) A well developed cake with periodic scouring may allow a good filter flux to be maintained for long periods of time.

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NOMENCLATURE

AV	=	Axial velocity of slurry being filtered
DOE	=	U.S. Department of Energy
EPDM	=	Ethylene Propylene Diene Monomer
HM	=	**H**-Canyon **M**odified Purex process and waste from that process is referred to as HM waste
NTU	=	Nephelometric Turbidity Unit
Purex	=	**P**lutonium **UR**anium **EX**traction process and waste from this process is referred to as Purex waste

SB6 = Sludge Batch 6, salt waste simulant
SRNL = Savannah River National Laboratory
SRS = Savannah River Site
TMP = Transmembrane pressure, the pressure difference that drives the permeate through porous media.

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