F/H EFFLUENT TREATMENT FACILITY FILTRATION UPGRADE ALTERNATIVE EVALUATIONS OVERVIEW

W. C. Miles, Jr., M. R. Poirier and D. F. Brown
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29802

ABSTRACT

The F/H Effluent Treatment Facility (ETF) at the Savannah River Site (SRS) was designed to treat process wastewater from the 200-F/H Production Facilities (routine wastewater) as well as intermittent flows from the F/H Retention Basins and F/H Cooling Water Basins (nonroutine wastewater). Since start- up of the ETF at SRS in 1988, the treatment process has experienced difficulties processing routine and nonroutine wastewater. Studies have identified high bacteria and bacterial decomposition products in the wastewater as the cause for excessive fouling of the filtration system.

In order to meet Waste Management requirements for the treatment of processed wastewater, an upgrade of the ETF filtration system is being developed. This upgrade must be able to process the nonroutine wastewater at design capacity.

As a result, a study of alternative filter technologies was conducted utilizing simulated wastewater. The simulated wastewater tests have been completed. Three filter technologies, centrifugal polymeric ultrafilters, tubular polymeric ultrafilters, and backwashable cartridge filters have been selected for further evaluation utilizing actual ETF wastewater.

INTRODUCTION

From start-up of the separation area (F and H) at the Savannah River Site (SRS) until November 1988, effluents from the separation processes had been disposed of in seepage basins. The F/H Effluent Treatment Facility (ETF) was designed to provide storage and treatment facilities to reduce wastewater contaminants (except tritium) to levels that meet established discharge limits to permit the safe discharge of the treated streams to the environment.

Construction of the ETF was necessary due to the retirement of the seepage basins, by November 1988, as required by the Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions. The aggressive construction schedule, required by this regulation, only permitted filter testing with small volumes of simulated feed.

The ETF was designed to treat process wastewater from the 200 - F/H Separation Facilities (routine wastewater) as well as intermittent flows from the F/H Retention Basins and F/H Cooling Water Basins (nonroutine water). The treatment process, as depicted in Fig. 1, consists of a series of steps (pH adjustment, crossflow ceramic microfiltration, heavy metals adsorption (mercury removal), granular activated carbon for organic removal, reverse osmosis, ion exchange) with evaporation of secondary wastes. This design provided for the treatment of 200 gpm continuous operation (2 trains @ 100 gpm each) and 300 gpm sprint operation (3 trains @ 100 gpm each). Since start-up of the ETF at SRS in 1988, the treatment process has experienced difficulties processing routine and nonroutine wastewater causing a significant reduction in the processing capacity. Bacteria and their decomposition products were identified as the primary source of fouling for routine wastewater.(1,2) For influent streams with high concentrations of bacteria and their decomposition products, bacterial fouling has resulted in typical flow rates of 25-30 gpm per train treatment of routine wastewater capacity and 15-20 gpm per train treatment of routine and nonroutine wastewater capacity. (Operational results indicate, in the treatment of nonroutine wastewater, that even a small proportional feed of the nonroutine wastewater causes significant fouling of the ceramic filters even when mixed with the routine wastewater.) Efforts were made to reduce bacteria and their decomposition products concentrations in the influents to the ceramic filter units to improve filter performance. Aluminum (III) nitrate addition has shown to improve filter performance on wastewater simulant when the influents contain high concentrations of bacteria and their decomposition products.(3,4) (Aluminum nitrate addition to ETF wastewater feed testing was performed between November, 1990 and December, 1991. Initial results indicate that this treatment may be effective on nonroutine wastewater. Efforts are in place to test the ETF feed over wastewater compositional variations). The nonroutine wastewater has low concentrations of intact bacteria and suspended solids but contains bacteria decomposition products, as well as algae and yeast. This biological fouling of the ceramic filter units has created the need to identify, evaluate, and test alternative filtration technologies to ensure that the ETF can meet Waste Management requirements.

This paper summarizes the need to develop an Alternative Filtration Program, the method employed to evaluate alternatives, and preliminary results of the test program.

FILTRATION PROGRAM BACKGROUND

Selection of the ceramic filters for the ETF was made in 1986 driven by the RCRA November 1988 deadline to cease flows to the seepage basins. This schedule only permitted testing with small volumes of simulated feed. This testing did not identify the fouling problem caused by biocontamination for the following reasons:

- the simulant used omitted the key fouling component (ie, bacteria and their decomposition products),
- variations in the wastewater composition of the ETF wastewater were not accounted for,

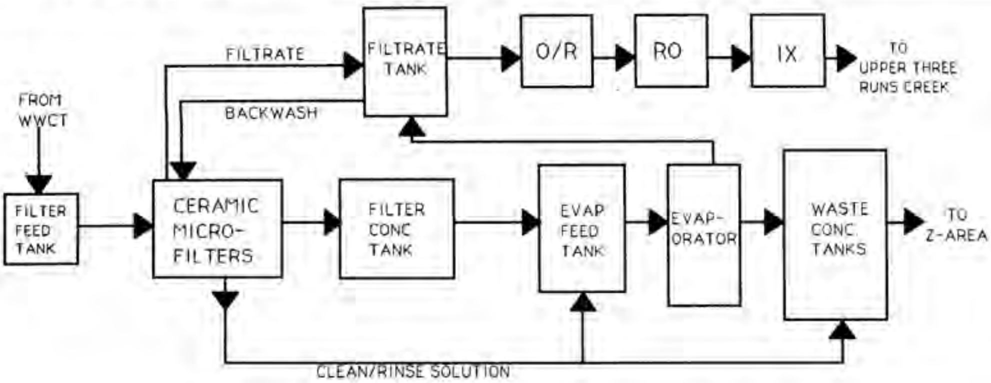

Fig. 1. F/H Effluent Treatment Facility process flowsheet.

- the history of the wastewater, in addition to its chemical composition, determines filter performance, and
- a relatively small volume of feed was recycled by recombining the filtrate and concentrate.

Original tests on the ceramic filter with simulant demonstrated good filtrate quality and minimal fouling. Plant performance and subsequent testing has shown that this testing did not adequately represent all operating conditions. Two large scale demonstrations (the vendor's full scale test of the first train and the facility's initial run) also showed good performance using a simulant without bacteria. These small volume feeds were also reconstituted by recycling filtrate and concentrate.

Several lessons have been learned as a result of the filter testing programs for the ETF project.

- Smaller units tend to not model flow dynamics accurately.
- The test feed cannot be one or two recipes of inorganics (even if upgraded with bacteria) but must reflect the variety of compositions and processing histories which will be seen on full-scale units.
- Small scale simulant tests should be used as a screening tool to indicate failure rather than success.
- Since the feed at the ETF varies (depending on which wastewater generating processes are operating and potential seasonal variations in the biological component), filter technologies should be demonstrated over an extended period of time utilizing a large feed volume.

ALTERNATIVE FILTRATION PROGRAM PRELIMINARY EVALUATION SUMMARY

These findings along with the need to ensure operation of the ETF at its design capacity (including biologically contaminated wastewater), have led to the initiation of an Alternative *Filtration Program*. This program began by identifying and evaluating various filtration technologies as replacements for the ceramic filters currently in use at the ETF. The purpose of the experimental program was to gather data on each filtration unit's performance based on quality and net quantity of filtrate. The comparison of similar data would then be appraised and correlated to select the 2 or 3 alternatives for further evaluation that provide the most promise for ensuring that the ETF will meet design based flow rates (100 gpm per train).

Several technologies were examined for their ability to effectively remove inorganic solids of the type, size and quantity found in the ETF influent. Both dead end (all the liquid passes through the filter medium) and cross-flow filtration (some of the liquid is used to sweep solids off the filter surface) were considered. Criteria in determining filtration unit performance were determined and are presented in Table I.

Nine alternatives were identified for testing - eight filters and one pretreatment option which are presented in Table II.

Pilot scale filters were tested using a standard wastewater simulant prepared according to the specification in Table III.

The simulant was prepared by dissolving the metals in HNO_3 (pH = 2-3), mixing, neutralizing with NaOH, and filtering.

TABLE I

Criteria Used To Determine Filtration Unit Performance

Filtrate Turbidity <1 NTU *
Filtrate Silt Density Index (SDI) <3 *
Simplicity of Operation
Anticipated Fouling
Requisite Cleaning
Minimal Waste Production
Volume Reduction
* Major Criteria

TABLE II

Filters Tested During Alternative Filtration Program Preliminary Evaluation

Ceramic (for baseline)
Centrifugal Ultrafilter
Tubular Ultrafilter
Backwashable Polymeric Cartridge
Deep Bed Filtration
Stainless Steel Mesh
Sintered Stainless Steel Powder
Tubular Fabric
Electrocoagulation Pretreatment
Centrifuge

TABLE III

Standard Wastewater Simulant Specification

Compound	Concentration (mg/1)
$NaNO_3$	1,257.00
$NaHCO_3$	100.00
NH_4NO_3	83.60
$Na_2SiO_3 \cdot 9H_2O$	67.50
$Al(NO_3)_3 \cdot 9H_2O$	37.80
$Fe(NO_3)_3 \cdot 9H_2O$	41.40
$CaCO_3$	10.70
Na_2SO_4	7.40
$NaNO_2$	2.30
NaCl	1.70
$MgSO_4 \cdot 9H_2O$	4.40
NaF	1.10
$MnCl_2 \cdot 4H_2O$	1.10
$Zn(NO_3)_2$	.90
$Ba(NO_3)_2$	.04
Tri n-butyl phosphate (TBP)	50.00

Each unit was operated in single-pass mode (ie, filtrate and concentrate were discarded rather than being mixed to reconstitute a recycle feed stream) with the exception of the centrifugal ultrafilter, which was fed from a vessel having a 30-minute turnover time. The units were operated for at least ten continuous hours with some units experiencing an occasional five to ten minute interruption when backwashing (cleaning was necessary). Samples were collected for analyses of the parameters identified in Table IV.

TABLE IV

Preliminary Evaluation Analytical Parameters

Turbidity	pH
Silt Density Index	Na
Total Suspended Solids	NO_3
Conductivity	Al
Fe	Si

Of the options tested, several produced filtrate that satisfied the 1 NTU limit. The two technologies showing the most promise as a result of the preliminary evaluation are the centrifugal ultrafilter (CUF) and the tubular ultrafilter (TUF). The deep bed filter also produced filtrate with the desired quality. However, the deepbed filter required a flocculent and required backwashing after 3-4 hours. A lot of the product water was used for backwashing resulting in poor volume reduction. The backpulsable polymeric cartridge showed some promise but needed more testing to establish credibility. The tubular fabric and centrifuge were rejected because they did not satisfy the filtrate turbidity limit, and the stainless steel mesh and porous metal filters were rejected because of fouling tendencies similar to those of the ceramic microfilter. The electrocoagulation pretreatment option was rejected because no significant beneficial effects on the particles were observed.

ALTERNATIVE FILTRATION PROGRAM PILOT TESTING

The preliminary evaluation performed on the Alternatives listed in Table II, with the standard wastewater simulant as specified in Table III, resulted in the process initiation to continue to evaluate the alternatives presented in Table V with actual wastewater in the ETF.

The centrifugal ultrafilter (CUF) pilot unit system is comprised of the rotor assembly (heart of the system) and supporting components. The rotor assembly consists of from two to ten polyvinylidene fluoride (PVDF) ultrafilter membrane disks sandwiched between two end plates to form a 24" diameter by ~4" thick stack. (A full-scale unit would be about 40" in diameter and approximately 340 PVDF membranes.) The stack is attached to a rotating hollow shaft. The rotor assembly is rotated at approximately 1000 rpm.

TABLE V

Filtration Alternatives to be Tested on Actual Wastewater in the ETF (listed in order of performance)

Centrifugal Ultrafilter
Tubular Ultrafilter
Crossflow Ceramic Microfilter (scaled down from ETF unit)
Backwashable Cartridge Filter

Feed enters the channel between two rotating membranes and flows radially outward along the membranes. Filtrate passes through the rotating membranes and is then discharged out radially from the periphery of the rotor assembly. Filtrate strikes the inside of an encapsulating housing where it drips down and is drained away. The solid particles which are rejected by the filter are swept away by the centrifugal force.(5) This system has been delivered to SRS and is scheduled for installation in early calendar year 1992.

The tubular ultrafilter (TUF) consists of a series of ~ ½" ID tubes (180 feet total length) lined with polysulfone membrane. (A full-scale unit would be similar but with many "tubes" in parallel.) The unit is operated in a feed and bleed arrangement which can be physically cleaned with spongeballs. This system is scheduled for delivery to the SRS in early calendar year 1992.

The pilot ceramic/cartridge filter unit (CCF) has been fabricated by SRS engineering staff. This unit consists of ~ 1/8" ID tubes (114 total tubes) in a parallel/series arrangement. (The existing full-scale unit at the ETF has a similar arrangement but with 4560 tubes (40x scale)). This unit has been installed and initial testing of the unit has begun.

CONCLUSIONS

The centrifugal ultrafilter (CUF) and tubular ultrafilter (TUF) were determined, based upon simulant feed (See Table III), to be the alternative filtration technologies that offer the most promise to the ceramic microfilter for treating ETF wastewater at design capacities. Therefore, efforts have been made to test pilot units of these technologies in comparison with a pilot unit of the ceramic/cartridge filter unit (CCF).

Pretesting of filtration units with actual wastewater and over a period of time sufficient to identify wastewater composition fluctuations, is essential to demonstrate a representative technology performance over all operating conditions. The installation of the pilot CUF and design and installation of the pilot TUF will continue followed by testing of these units with actual wastewater feed to the ETF. Testing of the pilot CCF will continue. Each unit will be tested over a six-month period to identify treatment difficulties associated with wastewater compositional fluctuations.

Results of the pilot tests of the CUF, TUF, and CCF are expected in late calendar year 1992. These results will be utilized to provide an accurate evaluation of the benefits of converting the ETF to an alternative filtration technology. Should an alternative technology prove beneficial, efforts will be *made to* initiate the design and construction of a full-scale unit at the ETF.

ACKNOWLEDGEMENTS

This paper was prepared in connection with work done under contract #DE-AC09-89SR18035 with the United States Department of Energy.

REFERENCES

1. D. J. McCABE, "Effects of Bacteria Concentration on the F/H - ETF." WSRC Report, WRSC-RP-90-798, 1990.
2. M. R. POIRIER and D. J. McCABE, "Lab Scale Microfilter Tests with Biologically Active Simulants." WSRC Report, WSRC- RP-90-342, 1990.
3. D. J. McCABE and M. R. POIRIER, "Improvement in the Filtration of Bacteria Containing Simulants by the Addition of High Levels of Aluminum (III) Nitrate." WSRC Report, WSRC-RP-90-566, 1990.
4. J. L. SILER, "Improving Ceramic Microfilter Performance at the F/H ETF via Aluminum Nitrate Addition." WSRC Report, WSRC- RP-90-562, 1990.
5. P. M. SHEARER, "Centrifugal Ultrafilter (CUF) Pilot Unit Hazards Study." BSRI Study Report, EWR W867713, 1991.