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TREATABILITY STUDIES OF ALTERNATIVE WASTEWATERS FOR METAL FINISHING EFFLUENT TREATMENT FACILITY

by

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TREATABILITY STUDIES OF ALTERNATIVE WASTEWATERS FOR METAL FINISHING EFFLUENT TREATMENT FACILITY

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ABSTRACT

The 300-M Area Liquid Effluent Treatment Facility (LETF) of the Savannah River Site (SRS) is an end-of-pipe industrial wastewater treatment facility that uses precipitation and filtration, which is the EPA Best Available Technology economically achievable for a Metal Finishing and Aluminum Form Industries. Upon the completion of stored waste treatment, the LETF will be shut down, because production of nuclear materials for reactors stopped at the end of the Cold War. The economic use of the LETF for the treatment of alternative wastewater streams is being evaluated through laboratory bench-scale treatability studies.

I. LETF DESCRIPTION

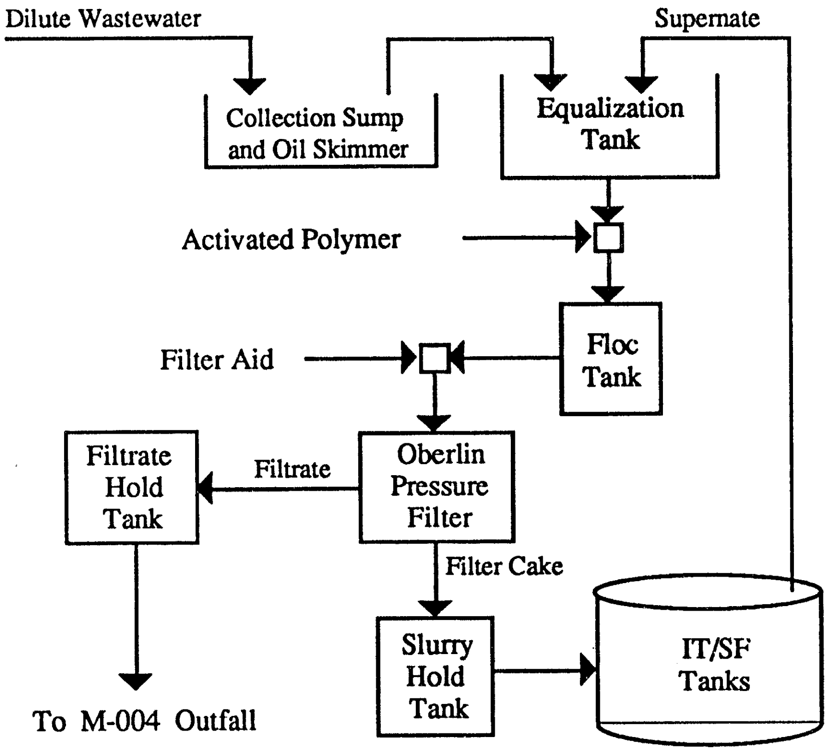
The LETF consists of three close-coupled treatment facilities: the Dilute Effluent Treatment Facility (DETF), which uses wastewater equalization, physical/chemical precipitation, flocculation, and filtration; the Chemical Treatment Facility (CTF), which slurries the filter cake generated from the DETF and pumps it to interim-status RCRA storage tanks; and the Interim Treatment/Storage Facility (IT/SF), which stores the waste from the CTF until the waste is stabilized/solidified for permanent disposal. 85% of the stored waste is from past nickel plating and aluminum canning of depleted uranium targets for the SRS nuclear reactors.

Federal Facilities Compliance Agreement (FFCA), between the Department of Energy (DOE) and the Environmental Protection Agency (EPA), mandates that this F006 mixed (hazardous and radioactive) waste be treated/stabilized for disposal. The IT/SF will be clean closed. Since startup of the LETF in 1985, more than 1,200,000 gallons of wastewater slurry have been transferred to the IT/SF tanks. The uranium and heavy metals precipitate at pH 12, and the slurry has separated into sludge and supernate. The supernate is being decanted from the IT/SF tanks and processed with production building wastewater by the DETF to reduce the volume of waste prior to stabilizing the sludge. A metal phosphate precipitation process using submicron filter media achieves less than 20 µg/L uranium (drinking water MCL) in discharged effluent. The DETF has been successfully optimized to achieve maximum efficiency and to minimize waste generation.

As shown in Figure 1, dilute wastewaters from three M-Area production buildings and two support laboratories are discharged through a process sewer to the DETF collection sump from which it is pumped to one of two equalization tanks. As one equalization tank receives wastewater, the contents of the other are processed through the DETF. Supernate is added while the equalization tank is filling. Sulfuric acid is added adjusting to pH 2.3 to dissolve all metals and to volatilize any residual carbonate. Aluminum sulfate is added as needed to precipitate excess phosphate. The wastewater is adjusted with caustic to pH 8.0 - 8.5, the optimum pH for metal phosphate removal.

As the wastewater is pumped to a flocculation tank, cationic polymer is added at an in-line static mixer via a flow ratio controlled metering pump with a water activation-mixing chamber. From the flocculation tank, the wastewater is pumped at 20-25 gpm to two Oberlin® pressure filters operating in parallel. Upstream of each filter, the wastewater passes through an in-line mixer where a perlite filter aid solution is added by flow ratio control to enhance filtration. The weight ratio of filter aid to total suspended solids (TSS) in the wastewater is controlled by adjusting the volume of water per bag added to the filter aid mix tank.

Figure 1. DETF PROCESS FLOW DIAGRAM



The filtrate is collected in hold tanks. After analysis confirms compliance with National Pollutant Discharge Elimination System (NPDES) permit limits, the filtrate is discharged to a small creek. Wastewater composition and filtrate quality are shown in Table 1.

The air dried filter cake is collected in 55 gallon drums that are emptied into the CTF slurry tank and pumped to an IT/SF tank. The filter cake from current production has a lower heavy metal concentration. Disposal cost will be less, so it is stored in a separate IT/SF tank.

II. CHANGE IN MISSION FOR SRS AND LETF

With the end of the Cold War came decreased nuclear weapons production and a new mission for the Savannah River Site. The mission of the site was no longer primarily to produce special nuclear materials, but to "meet current and future needs for national defense, environmental restoration and waste management, and related technology applications while protecting the employee and public health and the environment."

The change in mission significantly decreased Reactor Materials production activities, and waste minimization efforts increased. In June 1994, the DETF will complete treatment of the stored waste supernate. The remaining radioactive and hazardous (mixed) waste sludge in the IT/SF tanks will undergo stabilization by vitrification beginning mid-1995. The DETF will remain operational for a few years to treat laboratory effluent and wastewater generated by the sludge vitrification process. The economic use of the existing DETF to process other wastewaters is being evaluated. A variety of new wastewater streams are generated by the transition to new SRS missions and during decommissioning and decontamination (D&D) activities.

Bench scale treatability studies in the DETF laboratory simulate the process and evaluate alternative methods to match the existing plant to the chemical characteristics of these wastewaters. Constant flow filtration apparatus accurately measures

Table 1. WASTEWATER COMPOSITION

	IT/SF Sludge	IT/SF Supernate	Dilute Wastewater	Wastewater Filtrate
	mg/l	mg/l	mg/l	mg/l
Uranium	2,500	16	0.01	<0.01
Aluminum	5,000	3,100	286	0.176
Nickel	500	1.3	1.4	0.015
Lead	75	1.5	0.06	<0.013
Zinc	350	0.59	0.51	0.021
Copper	10	0.64	0.21	<0.002
Cadmium	-	5.6	<0.002	<0.002
Chromium	8	0.39	0.14	<0.002
Iron	200	5.4	5.4	0.012
Phosphate (as P)	1,500	1,100	26	12

the enhancement of capacity by combinations of polymers, filter aid and media. Filtrate quality is analyzed in the M-Area support laboratory. These studies identify alternative wastewater streams for the DETF, as well as determine if this technology is suitable for similar wastewaters at other DOE sites. Several studies have been completed with positive results, and other studies are in progress.

III. POWERHOUSE WASTEWATER TREATABILITY

Near the DETF is a coal fired powerhouse, which will continue to operate and supply steam heat to the large office, maintenance and laboratory complex. A permit application for construction of a new industrial wastewater treatment facility to remove solids from the boiler blow-down and wet ash scrubber effluent was rejected by SCDHEC. Conventional clarification technology would not remove arsenic from the combined effluent sufficient to achieve human health criteria in the small receiving surface stream, so the powerhouse wastewater is temporarily being trucked to another facility.

The powerhouse is upgrade of the DETF, but during the winter the volume of wastewater from the powerhouse greatly exceeds the DETF filtration capacity. Treatability studies were conducted to develop methods to remove arsenic and increase filter capacity without major modification of the DETF.

Other than a few large fast settling particles, the powerhouse wastewater is a colloidal mixture of fine particles that do not settle. The average total suspended solids (TSS) concentration is 2,300 mg/L and the pH 11.3 (See Table 2 for complete raw wastewater analysis).

The Celite® constant flow filter apparatus was used in bench scale tests to simulate the DETF process. The initial scouting test revealed that the granular particles were efficiently removed with Tyvek® T-980 disposable filter media even without filter aid addition (0.37 micron nominal particle removal). However, arsenic was not removed by simple filtration. Both filters could not reliably operate continuously at the maximum DETF design capacity of 80 gpm during the winter which would then be required to support the powerhouse.

Adjustment of the raw wastewater to pH 2.3 by addition of 10% wt sulfuric acid destroyed the chelate from the boiler blow-down. Adjustment to pH 6.7 then precipitated the arsenic for efficient removal by the sub micron Tyvek® filter media. The filtrate contained approximately 5 µg/L arsenic, but the interference by the high concentration of sodium ions made accurate analysis below 33 µg/L difficult. Filtrate analysis is shown in Table 2.

A 2-to-1 weight ratio of Renaissance TechFlo® 2000X perlite filter aid to TSS, and Praestol® polymers (30 ppm K290FL cationic followed by 7.5 ppm A3095L anionic polymer) achieved a 2.6×10^6 m/kg specific cake resistance. This "bridged cake" was formed by adding the anionic polymer seconds before addition of the filter aid (simulating addition of the polymer immediately downstream of the filter feed pump). Both filter aid and wastewater particles were observed to flocculate such that they stacked edge-to-edge in a very open bridge-like cake structure on the horizontal sheet of filter media. At 40 psig air pressure, the cake dried almost instantly with excellent separation from the median during cake discharge. An average wastewater flow of 40 gpm could be reliably maintained with one DETF filter operating.

insufficient wastewater sample to determine the cause, and analytical interference by other constituents prevented study.

Economic evaluation determined that installation of a dry bag house to eliminate the wet ash scrubber, which is the primary source of arsenic, and boiler blow-down treatment by the sanitary wastewater plant would be equally cost effective. Full scale demonstration of the DETF alternative is now unlikely.

Table 2. POWERHOUSE WASTEWATER ANALYTICAL RESULTS

	Raw Wastewater	Filtrate
	mg/L	mg/L
Arsenic	0.096	0.01
Aluminum	22.49	0.027
Cadmium	<0.006	<0.006
Chromium	0.063	<0.006
Copper	0.430	<0.012
Iron	19.74	0.029
Silicon	46.43	18.564
Zinc	0.120	0.005
Lead	0.083	<0.035
Nickel	0.040	<0.019

Use of existing high sheer pumps and tank agitators was simulated by placing the raw powerhouse wastewater in a blender for up to 12 hours. The arsenic concentration increased proportional to time under high sheer to 800 mg/L, but was removed with equal efficiency and filtration rate by the same optimum combination of wastewater treatment by acidification, neutralization, filter aid and polymer addition.

DETF processing of the hot powerhouse wastewater at 50^{o} C was also simulated. As expected, the solubility of arsenic proportionally increased in the filtrate. This problem can be avoided by using the segregated clean non-contact cooling water effluent from the powerhouse to cool the hot raw wastewater by heat exchange as it flows to the DETF.

Arsenic was not efficiently removed from one wastewater sample collected during a powerhouse process upset in which out-of-specification coal unburnable was inadvertently used. There was

IV. LEAD ACID BATTERY TREATABILITY STUDY

During D&D activities, a disposal method for lead acid batteries from Radiologically Controlled Areas is needed. These batteries cannot be recycled off-site until no potential for radiological contamination exists. By emptying the acid from the batteries, laboratory analysis of the radiological characteristics of the removed acid, and an external smear of the battery casings, these batteries can be cleared for reclamation. The battery acid is then used for neutralization and the lead is effectively removed by the filtration process. Based on this study, SCDHEC approved processing of up to 100 gallons of this battery acid per DETF wastewater batch.

V. OILY WASTEWATER TREATABILITY

Several areas on the site have accumulated oily wastewaters that are primarily rain water with a road oil film. The DETF has an oil and water separator, and the corresponding outfall is permitted by the

National Pollutant Discharge Elimination System (NPDES) for all necessary effluent characteristics. A study is currently underway to determine whether this wastewater can be disposed of in the DETF.

VI. DRAFT SITE TREATMENT PLAN

A Draft Site Treatment Plan is presently being developed to examine the Savannah River Site, as well as other Federal Facilities to identify wastes which may be treated in M-Area and the wastewater processed by the DETF. Several possible waste streams have been identified. An example is the wastewater resulting from nitric acid stripping of cadmium-plated hepa filter frames with low level radioactive surface contamination. If the DETF alternative is selected, treatability studies will verify that the mixed waste can be treated effectively, and resulting filter cakes vitrified with existing stored sludge.

VII. CONCLUSION

Waste generated from filtration of metal finishing wastewater during present LETF operations was minimized through treatability studies by (1) control of floc size through selection of polymer and optimization of dosage, (2) filter aid grade selection to match the floc size, (3) monitoring the filter aid quality to ensure uniform particle size distribution and no fines (<1%wt of < 1 micron and <4%wt of < 3 micron particles). With high quality perlite filter aid and proper selection of the filter belt fabric, a 7X reduction of waste filter media was achieved by conversion to cleanable belts (the generation of used belts is minuscule compared to the generation of used filter paper media). The generation of filter cake was also reduced 40%. Filtrate quality remained excellent, while present worth cost savings of these F006 mixed waste reductions total $1,900,000.

Other studies successfully completed are chromium-containing condensate found in heavy water towers during D&D, heat exchanger cleaning wastewater, excess and aged laboratory chemical treatment, and spilled chromate corrosion inhibited coolant.

The application of DETF treatability studies on alternative wastewaters resulting from SRS's new mission has significant potential for demonstrating this to be the most cost-effective method, especially when combined with the close-coupled vendor vitrification process for mixed waste volume reduction and stabilization.

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