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Waste Treatment at the Radiochemical Engineering Development Center

R. R. Brunson, W. D. Bond, F. R. Chattin, R. T. Collins, G. R. Sullivan, and R. H. Wiles

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Chemical Technology Division
Oak Ridge National Laboratory
P. O. Box 2008
Oak Ridge, TN 37831-6181
USA

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Abstract

At the Radiochemical Engineering Development Center (REDC) irradiated targets are processed for the recovery of valuable radioisotopes, principally transuranium nuclides. A system was recently installed for treating the various liquid alkaline waste streams for removal of excess radioactive contaminants at the REDC. Radionuclides that are removed will be stored as solids and thus the future discharge of radionuclides to liquid low level waste tank storage will be greatly reduced. The treatment system is of modular design and is installed in a hot cell (Cubicle 7) in Building 7920 at the REDC where preliminary testing is in progress. The module incorporates the following: (1) a resorcinol-formaldehyde resin column for Cs removal, (2) a cross flow filtration unit for removal of rare earths and actinides as hydroxide, and (3) a waste solidification unit. Process flowsheets for operation of the module, key features of the module design, and its computer-assisted control system are presented. Good operability of the cross flow filter system is mandatory to the successful treatment of REDC wastes. Results of tests to date on the operation of the filter in its slurry collection mode and its slurry washing mode are presented. These tests include the effects of entrained organic solvent in the waste stream feed to the filter.

Introduction

The Radiochemical Engineering Development Center (REDC) at Oak Ridge National Laboratory (ORNL) processes highly irradiated targets for the separation and recovery of valuable radioisotopes, principally transuranium (TRU) nuclides. Presently a waste treatment system has been fabricated and installed to pretreat essentially all liquid low level waste (LLLW) generated at the REDC. The waste treatment system is a module that incorporates (1) a resorcinol-formaldehyde (RF) resin ion exchange column, (2) a cross flow filtration unit, and (3) a waste solidification unit.

The waste treatment strategy is to remove the precipitated solids from the neutralized waste streams by processing the waste streams through a cross flow filter with the filtrate going to the LLLW and the solids going to solid waste storage. Neutralized waste is first treated using cross flow filtration to remove the insoluble hydroxide of the transuranium and rare earth elements as a concentrated slurry with concentrations running up to 10-20% by weight. The filtrate can be subsequently treated using an RF resin column to remove Cs. The concentrated slurry and the neutralized Cs eluted from the RF resin column are then transferred to the in-cell solidification unit. Waste canisters resulting from this treatment system will be stored onsite while awaiting final disposal.

Three REDC waste tank pit tanks (F-111, F-115, F-126) are used in conjunction with the waste treatment module to carry out this waste treatment strategy. These are shown in Figure 1. The 550-gallon capacity F-115 tank is used collect various waste from the many REDC processes for acidification and characterization sampling. From F-115 the acidic waste is transferred in batches into a caustic heel in the 125 gallon F-111 tank for neutralization and sampling. The neutralized waste is then pulled up from F-111 to the waste treatment module, T-780, in 13-15 liter batches. The neutralized solution is filtered through the cross filter with the filtrate routed to the third tank, F-126. F-126 is a 1200 gallon tank that collects all the REDC LLLW until it is transferred out of the building into the ORNL LLLW collection and treatment system. If the

Figure 1. Waste pretreatment schematic for REDC.

filtrate contains Cs, the module offers an option of treating the filtrate through an ion exchange column to remove the Cs; however, the majority of the cesium contaminated waste is generated during target dejacketing operations and will be transferred directly through the ion exchange column after filtration by conventional means. The concentrated slurry from the filtration system is periodically transferred from the T-780 feed tank to a solidification unit where the slurry is dried using a clam shell heater.

Waste Treatment Module

The approach taken to treat waste at the REDC was to build a treatment module using existing equipment and framework designs that could be installed in the right (equipment) rack position 7 (right side of Cubicle 7) in Building 7920. The module contains a feed tank, pump, cross flow filter, air jet (vacuum), ion exchange column, solids-can, heater, automated valves, hand valves, and diversion valves. Figure 2 is an illustration of the module and equipment.

The heart of the waste treatment module is a continuously operated filtration loop. The feed solution is pumped through the loop using a ~2 g.p.m. flow rate and returned to the feed tank concentrating the feed solution as the filtrate is removed at a 0.2–0.3 L/min rate. A 22 liter feed

Figure 2. Waste Treatment module.

tank is repeatedly pumped down to ~5 liters and refilled with neutralized waste. The pump used on the module is a Wilden M-2 model double diaphragm air driven pump. The flow rate is controlled by regulating the air pressure to the pump with an electronic air regulator. A Mott Metallurgical Corporation inertial cross flow filter containing three stainless steel porous filter elements is used to filter the waste solutions. The concentrated slurry is repeatedly transferred to a stainless steel 4 liter can that will be vented using a HEPA filter when it is removed from the rack and placed in storage. The canister is heated to evaporate the slurry to dryness using a clam shell heater designed to fit the canister and mount on the module. The can temperature is held at 100–105°C to slowly evaporate liquids using an electronic heater controller. A 7.2 liter capacity ion exchange column, using an RF resin, can be used to remove Cs from the filtrate from the cross flow system or it can be used to remove Cs from other neutralized waste streams. A 3.0–3.5 liter resin bed will be used in the column which is operated using gravity flow.

The module is operated using a computer system to automate routine operations to the extent allowed by available instruments. This automation will reduce the time that normal processing operations will be interrupted to operate the waste system. Automated tasks include transferring waste to the module,

controlling the pump flow rate, and back flushing the filter on a set time schedule. The computer system is programmed to activate control valves and pressure regulators that allow a task to occur. The computer is also programmed to monitor the waste operation and warn operators of unusual events or operations that may require special attention.

Removal of Cesium by Ion Exchange

Removing Cs from the REDC waste will be done using an RF resin in a cation-exchange column. The RF resin was developed at the Westinghouse Savannah River Laboratory and is highly specific for the removal of Cs from an alkaline waste of high sodium content.¹ It is particularly advantageous for REDC because it permits treatment of the highly alkaline (2M NaOH) aluminum decladding wastes.

This resin has received considerable study.²³⁴ The resin is a condensation polymer of resorcinol and formaldehyde, and like other phenolic resins (such as Duolite CS-100) it can be expected to suffer loss of capacity by oxidation of its phenolic (OH) groups. The oxidation instability has been the largest objection to both widespread use and large-scale application of phenolic resins. Additional degradation by slow hydrolysis may also occur. In typical usage of Duolite CS-100 at the ORNL wastewater treatment plant, there was extreme capacity loss after 39 cycles. This is not necessarily an objection at the RECD, where waste to be treated is relatively small in volume. Limited operational life (~5 cycles) of RF resins could be accommodated since only a few liters (<10) per annum would be consumed.

Removing Cs from an LLLW stream using the RF resin has been demonstrated at the REDC⁵. The two in-cell demonstrations resulted in standard breakthrough curves for loading performance and elution profiles for the Cs stripping performance. The feed solutions were alkaline dejacketing solutions created during the dissolution of Mark 42 target segments. The feed solutions typically had an [OH⁻] range from 1–2 M with gamma activity levels of 2.6×10^8 and 3.4×10^7 Bq/mL.

The characteristics of the in-cell tests are shown in Figure 3, where the ratio of the ¹³⁷Cs effluent concentration C to ¹³⁷Cs feed concentration (C₀) is profiled with the dejacketing solution throughput. The initial breakthrough point for the runs was in the range of 85–92 column volumes (CV). The first in-cell run (M5-RC-EXP1) reached only a 17.7% breakthrough point due to an excess of the resin. The second in-cell run (M5-RC-EXP2) used a larger volume of feed material and exhibited a fully developed breakthrough curve similar to a bench-scale run

Figure 3. Cesium loading profiles of two in-cell runs and a bench-scale test.

(SRS-B-2) performed in the laboratory using a 4.45 mL fixed-bed column of the RF resin. The SRS-B-2 and the M5-RC-EXP2 runs reached the 50% breakthrough point at ~110 CV. The distribution coefficient (K_d) values for the bench-scale run SRS-B-2 and the in-cell run M5-RC-EXP2 were based on the 50% breakthrough point and found to be 237 and 283 mL/g, respectively.

Figure 4 profiles the stripping data from the in-cell runs M5-RC-EXP1 and M5-RC-EXP2. The resin was stripped with a 2 M HCl solution. Samples were pulled as the strip solution exited the column. Due to erratic flow, caused by siphoning at the start of the M5-RC-EXP1 run, the elution peak went undetected; however, a complete elution profile was obtained during the M5-RC-EXP2 run. The highest Cs concentrations were found as 1–2.5 CV of the strip solution passed through the resin bed, indicating that the vast majority of the material is actually removed from the resin in less than 3 CV.

Figure 4. Cesium concentration profiles during resin elution with 2 M HCl.

The stripping data revealed that a 1.5 L resin bed was loaded with 1130 Ci of ^{137}Cs and 146.9 Ci of ^{134}Cs during M5-RC-EXP1 and 1160 Ci of ^{137}Cs and 141 Ci of ^{134}Cs during the M5-RC-EXP2 run. Based on the stripping data, the resin loaded 27.6 g of Cs during M5-RC-EXP1 and 28.4 g of Cs during M5-RC-EXP2. Samples of the eluted resin bed revealed the percentage of Cs remaining on the resin was 0.006% of the material loaded and indicates that essentially all of the Cs was removed during the stripping operation.

Stripping the Cs from the resin with HCl converts the resin to an H^+ form. The resin was converted back to the Na^+ form between runs by washing the resin with 12 CV of 2 M NaOH using an upflow path to fluidize the resin for maximum liquid to resin contact. The resin remained in the caustic wash for ~18 h before loading to ensure that the resin was fully converted to the Na^+ form.

The RF resin demonstration indicated that the 1.5 L resin bed averaged loading ~1300 Ci of Cs and ~30 g of total Cs. An initial Cs breakthrough occurred as 85–92 CV of alkaline waste passed through the resin bed. The majority of the Cs was stripped from the resin bed with only 2 CV of 2 M HCl. Based on the in-cell demonstration, a 3–3.5 L resin bed of RF would process the Cs produced during the dissolution of 2–3 Mark 42 target segments.

Cross Flow Filtration

A cross flow filtration unit has been employed for removal of solids. The inertial cross flow filter is a nonlogging filter designed for particulate or sludge concentration and liquid recovery that contrasts with dead-end filtration where the process stream passes perpendicular to the plane of the filter medium and the particles accumulate on the filter medium surface.⁶ The filter is three Mott Metallurgical Corporation inertial cross flow filter elements (3/8" OD, 1/4" ID, 24" length, 0.5 μm pore size, 316 LSS porous metal filters) housed in 1 1/2" OD 316 LSS tubing (0.065" wall) with 1/2" OD 316 LSS tubing connectors for feed flow (0.065" wall) and 3/8" OD 316 LSS tubing connector for filtrate flow. The cross flow filter is operated using a slurry velocity of ~20 fps and applying back pressure on the filter which is referred to as the filter pressure. With a differential pressure across the porous wall, a portion of the liquid phase of the main stream will flow through the porous wall into the annulus as clear filtrate and exit the outlet. The main stream is returned to the feed tank resulting in an increased concentration of solids.

Figure 5 demonstrates the typical filtration pattern of a cross flow filter. The saw tooth effect is created by back flushing the filter. Back flushing is necessary to dislodge the surface membrane that forms on the filter tubes. Typically, a new filter will have high filtrate rates until a surface membrane is formed on the filter tubes. The filtrate rate will decline and eventually go to a steady state. Back flushing the filter clears the surface membrane and increases the filtrate rate. Therefore, a periodic back flush is used to increase the filtrate flow. Back flushing the filter is carried out with air over the filtrate on the filtrate side of the tube. The frequency of the back flush can range from one to 30 minute intervals. A 15 minute back flush interval was used for the filter test and module check out tests.

The cross flow filter was evaluated using a filter test loop. A 22 liter tank was used as the feed tank. The slurry was pumped through the loop using an air driven double diaphragm pump. The pump flow rate was controlled using an air regulator to adjust the 100 psig supply pressure. A restricting valve upstream of the cross flow filter was partially closed to generate a tube side filter pressure. The filter was back flushed using an air reservoir set at 70–80 psig to drive the filtrate back through the filter elements.

Figure 5. Typical filtrate patterns of a cross flow filter.

A synthetic feed solution was used in testing the cross flow filter. The feed consisted of ~1% wt. each of $\text{Al}(\text{OH})_3$, $\text{ZrO}(\text{OH})_3$, and $\text{Fe}(\text{OH})_3$ suspended in a 0.1 M NaOH and 0.5 M NaNO_3 solution. The metal hydroxide feed was developed by dissolving the nitrate form of the materials in water. The salts were then converted to hydroxides by precipitating the solution with 2 M NaOH solution to yield the metal hydroxide forms. The liquid was then decanted and the precipitate was added to 0.1 M in NaOH and 0.5 M in NaNO_3 to give the 3% wt. metal hydroxide. This synthetic feed solution was used on all cross flow filter tests and module tests.

Typical flux behavior is shown in Figure 6. Normally, the characteristics of a cross flow filtration system will indicate that as the slurry concentration increases the permeate flux will decrease due to the build up of solids in the main feed stream. The process parameters investigated were slurry flow rate and filter pressure. The slurry flow rate was set by the amount of pressure selected to operate the diaphragm pump. The operating pressure of the pump is called the slurry pressure which is the pressure developed in the system if the flow is valved out completely. The filtrate rate was recorded as the filtrate flux ($\text{L}/\text{min m}^2$) which is the filtrate rate relative to the surface area of the filter. Laboratory tests have indicated that the maximum filtrate flux is achieved using a differential pressure range of 15–20 psi between the slurry pressure and the filter pressure. Figure 7 shows the typical effects that slurry flow rate and filter pressure have on the filtrate flux. Based on these results, the cross flow filter used on the module will be operated using a slurry pressure of ~60 psig with a filter pressure of 40–45 psi.

Figure 6. Typical filtrate flux and solids concentration profiles.

Figure 7. Typical effects of slurry flow rate and filter pressure on the filter flux.

The normal process schemes at REDC involve organic extractions; therefore, it is reasonable to expect that organic reagents will be entrained into the aqueous waste streams. The effects of organic contamination on the 3 wt.% synthetic slurry were investigated using the Cleanex solvent extraction reagent di (2-ethylhexyl) phosphoric acid (HDEHP) diluted with a normal paraffin hydrocarbon (NPH).

A slurry pressure of 49 psig with a filter pressure of 40 psig was used in the tests. The filtrate side of the filter assembly was connected to the vented feed tank at atmospheric pressure for total recirculation. The filter was back flushed at 15 minute intervals. The slurry flow rates were set at 2.7 ± 0.3 g.p.m. Filtrate measurements were taken at fixed increments after each back flush. Total volume of filtrate removed was determined by direct volumetric measurement and by intermittingly measuring the decrease in feed volume.

Several tests were used to examine the effect of organic contamination. First baseline filtrate flux measurements were performed using water. Next filtrate flux baseline measurements were performed using a 0.1 M NaOH solution. A comparison of the baseline results indicated that the filter flux was ~90% lower for the NaOH solution. This reduction in flux was attributed to excessive foaming during the NaOH solution tests. Tests were then performed to determine the flux potential for similar alkaline solutions contaminated with Cleanex solution. Cleanex solution was added incrementally to 10 L of 0.1 M NaOH in the filtration test loop between runs to yield suspensions of 0.1, 0.2, and 0.4 vol. % 1 M NaOH HDEHP in NPH. Average filtrate flux data for these runs is provided in Table 1.

Table 1. Average filtrate fluxes for 0.1 M NaOH solutions of varying concentrations of Cleanex solution, 1 M HDEHP in NPH.

Cleanex solution conc., % Vol. 1 M HDEHP in NPH in 0.1 M NaOH	Average Filtrate Flux, ^a		
	1 min a.b.f.	8 min a.b.f.	12 min a.b.f.
	L / min m ²	L / min m ²	L / min m ²
0.0% ^b	22.5	10.0	8.7
0.1%	16.3	8.0	6.3
0.2%	21.4	11.9	9.5
0.4%	17.5	10.8	8.8

^a Values are for the average flux of runs measured 1, 8, and 12 minutes after a back flush.

^b 0.1 M NaOH solution with no organics.

Upon mixing in the filtration test loop, the Cleanex solution organic appeared to form a fairly stable opaque emulsion in the 0.1 M NaOH. As with the 0.1 M NaOH solutions, considerable foaming was observed with the Cleanex contaminated NaOH solutions while circulating in the

filtration test loop, and the presence of the organic appeared to compound this effect. Filtrate samples from these suspensions had the same appearance as the opaque, emulsified feed, indicating that the cross flow filtration unit was not separating all of the organic from the feed. Phosphate and total organic carbon analysis of samples of feed and permeate from these runs were inconclusive in determining the distribution of Cleanex solution organic in the feed and the filtrate. The filtrate flux did not appear to be appreciably affected by the addition of Cleanex solution to the NaOH solution.

To gauge the effects of small amounts of dissolved and suspended Cleanex solution on the flux potential of the 3 wt.% metal hydroxide, Cleanex solution was added incrementally to the filtration test loop between runs to yield 0.1, 0.2, 0.4, and 1.0 vol.% 1M HDEHP in NPH metal hydroxide slurries. Comparing the test to similar runs using no organic, it was discovered that permeate flux decreased slightly with each increase in Cleanex solution. The average filtrate flux for each simulated waste slurry test is plotted in Figure 8. Unlike tests with 0.1 M NaOH contaminated with Cleanex solution, the metal hydroxide slurries contaminated with Cleanex solution did not exhibit any foaming.

Figure 8. Filter flux profile using a synthetic feed contaminated with Cleanex extractant.

Slurry concentrating runs were then performed by removing the filtrate and allowing the solids concentration to increase. The 3 wt. % metal hydroxide solution was concentrated without organic contamination. Then the 3 wt. % metal hydroxide feed solution was contaminated with 1.0 vol. % Cleanex solution. These tests were repeated. The filter and filtration loop were cleaned between each run using a 5 wt. % solution of HNO_3 .

The filtrate flux for each run is plotted in Figure 9, and the slurry concentration profiles are shown in Figure 10. The average filtrate flux for both slurries was found to increase slightly

Figure 9. The effects of contaminating the synthetic feed with 1 vol. % Cleanex extractant.

Figure 10. The effects of 1 vol % Cleanex extractant on slurry solids build up rate.

between sets of runs. This was attributed to the cleaning process, as the filter pore size may have been slightly increased after each HNO_3 cleaning cycle. Similar flux patterns were observed for both slurries from run to run.

Results from these experiments indicated that the organic solutions will inhibit the filter flux. These results were expected. Organic solutions commonly emulsify and clog filtration systems. The filter flux measured in the solids concentration runs ran about 1.5–2.0 L/min m^2 less than the runs not contaminated with Cleanex solution.

Waste Solidification

Waste solidification is accomplished by diverting the concentrated slurry from the filtration loop to a canister. A conductance probe is used to indicate when the slurry level in the can reaches 80% of the can volume so the transfer can be stopped before overfilling the can. The canister is a 4-liter stainless steel canister designed similar to Mark 42 target canisters (existing equipment) that permit the use of existing equipment to position and remove the can from Cubicle 7. The canister (solids-can) is position in a clam shell heater used to evaporate the slurry to dryness.

The clam shell heater is operated from 110 to 140°C to deliver a solids-can temperature ranging from 95 to 105 °C. A programmable controller is used to slowly ramp up to the desired temperature range. Slurry evaporation rates averaged 3 liters per 24 hours. The solids-can will be heated 24 hours per day to allow the solids to bake during any delayed transfer intervals. Once the solids can is filled to an approximate 2 liter volume with dried solids, the solids will be baked for ~5 days before solids-can is removed from the heater. When the solids-can is removed from the module it is capped and vented using a certified HEPA filter to prevent material releases.

Sodium Nitrate Washing

To avoid the build up of sodium nitrate in the solids-can, the slurry will be washed before transferring solids to the solids-can. Three water washes of the synthetic feed reduced the feed nitrate content from 25000 ug/mL to 780 ug/mL resulting in the removal of 97% of the NaNO_3 . The sodium nitrate washing profiles are shown in Figure 11.

This procedure was developed in the laboratory using the previously described synthetic metal hydroxide feed. It was determined that one water wash with a dilution factor of 5.3–5.7 will reduce the nitrate content of the feed ~65–75 %. The dilution factor is the total volume of the wash, including the slurry solution, relative to the concentrated slurry as describe in the following equation.

$$\text{DF} = V_t/V_s,$$

V_t = Total volume of the water wash and concentrated slurry,

V_s = Initial volume of the slurry.

Figure 11. Sodium nitrate removal using three water washes.

Waste Treatment Control System

The routine operation of the waste treatment equipment has been automated by the use of an industrial computer system. All the electrical components of the waste treatment system, with the exception of the waste solidification evaporation system, are connected to the electronic inputs and outputs of the industrial computer. The electrical components of the waste treatment system are electronic differential pressure transmitters, an electronic pressure transmitter, pressure switches, electronic conductance probes, electric solenoid valves, an electronic controlled pressure regulator, and a custom photo-metal instrument control panel comprising electronic indicators, lights, and switches. The evaporation system of the waste solidification unit is monitored and controlled by both a temperature controller and a high-temperature alarm indicator/switch.

The industrial computer that is used to monitor and operate the waste treatment system is a SIXNET industrial controller called an IOMUX (pronounced I-O-Mux). The IOMUX is a smart real-time multitasking distributed controller that integrates data acquisition and task control into a single synergistic solution. The firmware embedded into the IOMUX is programmed using SIXNET C Industrial Language (SCIL). SCIL is an ANSI "C" programming language with added libraries that allows "C" to perform real-time multitasking and control the instrumentation connected to the IOMUX. Multitasking means time slicing to execute several tasks (subprograms) simultaneously instead of executing the subprograms sequentially one at a time. Real-time means you control the multitasking to ensure time-critical operations are carried out when you need them. The SCIL program that executes in the waste treatment IOMUX consists of 12 separately scheduled independent subprograms. The SCIL subprograms consist of tasks that

calculates the volume and densities of the system tanks, calculates the filtrate rate of the filtration, controls transfers of solution between tanks, controls the filtration loop components, performs the sequence and timing of the back-flush system, and indicates and alarms all system conditions.

The transfer system used to fill the T-780 module feed tank is an air jet system controlled by an SCIL subprogram. The jet is a venturi system where 100-psi air is routed through the jet to create a vacuum of 23–25 in. Hg in T-780. The vacuum lifts the neutralized waste solution from the F-111 tank and fills T-780. When the liquid level in T-780 reaches ~18 L, the jet is automatically shut down. During normal operation, the liquid level of T-780 is determined by measuring the differential pressure between two probes in the tank. One probe, which is submerged in the solution, extends to within a quarter of an inch of the bottom of the tank. The other probe, which is the reference leg, only extends ~3 inches into the tank and is never covered by solution. The pressure between the two probes, which is measured using an electronic differential pressure transmitter (level transmitter), is directly proportional to the liquid level in the tank. In order to prevent solution from being pulled up into the level probes and into the level transmitter during vacuum transfers, the level probes have valves located on the rack that isolate the vacuum from the level transmitter. Since the level transmitter is isolated or off-line during transfers, a conductance probe was installed in the T-780 tank to detect when the liquid reaches the 18 L level. When the liquid contacts the conductance probe, a circuit is completed and alerts the SCIL task to shut down the air supply to the air jet stopping the transfer.

The SCIL subprogram that accomplishes the T-780 transfer performs several tests and steps before air is supplied to the venturi jet. First the SCIL subprogram sets a flag to signal all other SCIL subprograms that are running that a T-780 transfer is in progress. This flag is used to stop the pump, close the filtrate valve, suspend calculating of the volume and filtrate rate of T-780, and prevent an F-115 to F-111 transfer from starting. Next, the current level of T-780 is measured and stored. The stored level is used after the transfer to determine if a successful transfer was completed. After the level measurement is determined a normally open solenoid valve is energized to remove the air from the level probe's valves on the rack to isolate the level transmitter from the vacuum. A pressure switch is used to verify the operation of the solenoid valve. If the level transmitter is successfully isolated, the normally closed solenoid valve to the venturi jet is opened; otherwise the transfer is suspended and an alarm is annunciated on the panel board of the cause. A pressure switch also verifies the operation of the jet solenoid valve and proper operation is required for the transfer task to continue or the transfer is suspended and another alarm is annunciated on the panel board identifying the problem. If the jet solenoid valve operated successfully, a continuous loop monitors the T-780 conductance probe, the instrument panel "J-784 JET CONTROL STOP" switch, the volume of F-111, and the elapsed time. When any of these events become true, the air is removed from the jet, and a test is performed to determine what stopped the transfer. If the "STOP" switch or a low F-111 volume interrupted the transfer, the system is put back into operation as before the transfer started. If the elapsed transfer time was too long, or a premature cutoff by the conductance probe occurred, an annunciator signals the operator what caused the transfer to stop before the system is placed back

into operation. The T-780 transfer system has two modes of operation, and is started by a 3-position switch on the control panel. The "HAND" or manual switch position starts a transfer immediately. The "AUTO" or automatic switch position starts a transfer anytime that the volume of T-780 is at or below 5 L. Neither switch position will start the transfer process if a transfer between tank F-115 and F-111 is in progress, the solution in F-111 has not been sampled, or the conductance probe in T-780 caused a premature transfer suspension during the previous transfer.

A conductance probe is also used in the solids transfer operation. It was not feasible to have liquid level probes in the can since the probes would plug with dried solids. A conductance probe was installed in the can at a level of ~3.2 L (~80% can volume) to prevent overfilling the can. When the transferred slurry reaches the 3.2 L volume level, a lighted alarm is activated indicating that the transfer must be terminated. Transferring the concentrated slurry is a manual operation that is critical. If the solids-can is overfilled, the excess slurry enters the vent line and could possibly plug the module off-gas line. The conductance probes are critical to the operations. A check of the probe circuitry is performed to determine that the probes are functioning.

Back flushing the filter is an automated operation that is programmed to occur at 15-minute intervals whenever the filtration pump loop is operating above 5 psi. Back flushing is accomplished using air over the filtrate to push the filtrate back through the pores of the filter to remove the surface membrane on the filter. An air volume under high pressure is captured between two solenoid valves while another solenoid valve, down stream of the filtrate, is closed. The trapped air is then released into the filtrate line and forces the filtrate back through the filter. A panel switch can also manually start the back-flush sequence whenever the filtration pump loop is operating above 5 psi.

Before solution is transferred to the T-780 module feed tank, transfer criteria must be met. The F-111 neutralization tank must be sampled and determined to be a neutral or slightly caustic solution after each transfer from F-115 to F-111. This operation will prevent the possible transfer of acidic solution to T-780.

The temperature of the evaporation system and the solids-can is monitored using thermocouples. The heater is controlled using an electronic controlling system that allows the heater to be slowly ramped to the desired temperature.

Module Status and Future Work

The waste treatment module has been fabricated and installed in Cubicle 7 in Building 7920. Equipment check outs are scheduled from October through November 1997. The module is being operated using a personal computer with *visual basic* programs to communicate with the SIXNET system. The final control system will be a panel board on the master control room panels. The installation of the control panel and the programming will continue through the equipment check outs and testing. The waste system is scheduled to begin hot testing operations in the spring of 1998.

Based on testing, the cross flow filter will be operated to deliver a minimum filtrate rate of 200 mL/min. The slurry pump will be operated using 60–65 psi air pressure to pump the slurry through the filtration loop. The back pressure applied to the filter will range from 40–45 psi. Assuming that a waste tank is only filled to 80% capacity, F-115 would be processed through the module in ~140 hours. The concentrated slurry will be washed in the T-780 feed tank with three 13–14 L water washes to reduce the sodium content by ~97% before transferring the slurry to the solids-can. Tests reveal that entrained organic will pass through the filter. To help prevent organic solution being transferred to the waste treatment module, a 50-liter heel will be kept in the neutralization tank F-111 and a 100-liter heel will be kept in the F-115 tank.

The ion exchange column will contain 3–4 L volume of an RF resin capable of removing ~3000 Ci of Cs or processing ~3 Mark 42 target segments. The resin will be stripped with 10–15 liters of 2M HCl.

Future work on the waste treatment system will include developing processing alternatives, programming the computer control system, developing decontamination methods for the removal of the solids-can, and developing methods to remove the solids-can from the building. Alternative processing methods may allow waste to be transferred directly to the waste module bypassing the F-115 tank. Programming the operations will continue as the module is checked out for operations. Decontamination of the solids-can will involve developing an electro-polishing system that will allow the can to be removed from the cubicle free of surface contamination. The removal of the solids-can will be via a slug chute that is normally used to drop materials into the cubicle. The slug chute must be kept free from contamination in order for operators to use the chute to quickly pass items into the cubicle. The methods for removing the solids-can have not been finalized. An independent carrier that will mate to the existing slug chute may have to be fabricated. The carrier will then be used to transport the canister to another transportation cask or carrier. These tasks will be focused on during 1998. The waste treatment module is scheduled to begin testing with waste from newly dissolved irradiated targets during the summer of 1998.

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