

New Generation Dresden NPP Demineralizer Vault Cleanup Project - 8377

Mark S. Denton, Ph.D., CET, CHMM, REP
Vice President, Technology Development
Engineering and Technology Division
Energy Solutions, Inc.
1009 Commerce Park Drive, Suite 100
Oak Ridge, Tennessee 37830

Kent Forrester
Energy Solutions, Inc.
140 Stone Ridge Drive, Suite 500
Columbia, South Carolina 29210

Miguel Azar
Corporate Radwaste Manager
and Tom Britt
Chemistry/Radwaste Specialist
Exelon Nuclear
Chicago, Illinois

INTRODUCTION

Nukem Corporation (now Energy Solutions) was contacted in April 2007 regarding a novel approach to cleaning out a demineralizer vault containing sludges, stored for some six years, which were poorly characterized. Being some 30 feet below the operating surface and containing a 10 foot-diameter demineralizer vessel in the middle of the vault (with sludge accumulation below it), access was particularly challenging and operational space limited. The sludge was about 2-3 feet in depth with 5-6 feet of supernatant on the surface, and, from best estimates from the plant were thought to be from concentrated waste (CW) at ~7-8 R/Hr on contact dose rates, with a conductivity of ~90 micromho/cm, and pH of ~8.8. A previous attempt at cleaning out the vault had been attempted by wanding the material out of the vault manually and dewatering in a High Integrity Container (HIC). This attempt was terminated due to the high dose to personnel and the almost instant plugging of filters by the tacky and extremely fine material.

A novel approach was then proposed and accepted, on a time and material basis under an existing contract, to first treat the sludge and supernate by the patented SAFE™ Solution, an ElectroCoagulation (EC) technology utilizing Seeding And Filtration Electronically. The sludge had a loose layer on top and became increasingly packed toward the bottom. To break up the sludge, two Grindex slurry pumps (350 gpm each) were used to break up and slurry the material while a 30 gpm Grindex feed pump fed the six (6) cell EC skid. This system was put on recycle to the vault until samples showed that the material had been flocced appropriately, settled rapidly and was readily dewaterable by standard HIC sheet filters (20-25 micron). The treated material was then transferred to the HIC, placed two elevations above the vault floor in a cask carrying low-boy trailer. This treated slurry was then dewatered via standard side, center and bottom sheet filters over a one week period versus the three weeks it had taken previously. The resulting, clear supernate was then returned to the vault. A bottom dewatering leg was utilized for final dewatering verification prior to sealing the cask and shipping to the Clive site.

The SAFE™ System was a specially designed six-cell skid, with a 30 gpm throughput, and extended, angled legs to penetrate the sludge and rest on the bottom of the vault. The EC skid was outfitted with recycle and product valves for returning product to the vault or pumping it to a trailer mounted HIC-in-

Cask in a truck bay some 30 foot above and another 50 feet from the top vault rail. The segregated (cold) Chem-Add System (alum addition for pH and conductivity adjustment, if needed), the two chopper pump controls, feed pump controls and EC control panel and power supplies were also located at the remote 50 foot above vault floor level. All personnel dose and ALARA goals were thus surpassed.

The entire system was put into place in this somewhat difficult scenario during May 2007 and operation begun. Once the product samples were determined to be adequately flocced by EC and the 20-25 micron floc was found to readily settle and successfully dewater in a portable vacuum assembly (i.e., the tackiness and fineness had been overcome), the recycle valve was closed and the product valve opened and the product slurry was pumped up to the trailer-mounted fill head and into the HIC in campaigns. As a precautionary measure, the HIC was a specially designed Press-Pak with internal sheet filters, final dewatering leg, and an expandable, outer bladder if needed for final dewatering. It was found after filling the first HIC of two that the material dewatered and passed final dewatering tests without the need for the precautionary Press-Pak feature.

An additional challenge was encountered when an unknown source of in-leakage was found to be filling the vault by several feet a day. This in-leakage was thought to be coming from pipes to the demineralizer vessel and resulted in a much higher conductivity (2500-3000 micromho/cm) and lower pH (brought the overall pH down to ~7.6) than expected. The SAFE™ System was able to process this additional volume while simultaneously processing the slurried sludge. Furthermore, the original estimate of 1 to 1.5 weight % slurry was found to be approximately 15-20 wt. % routinely and spiked over 30 wt. % on some samples. While not an ideal situation for any water treatment process, where high solids fouling and plugging could occur, the system was still able to handle and process the material.

Original estimates by the evaluation team estimated it would take some 11 to 12 HICs to remove the vault contents to a remote location for treatment, dewatering and final shipment. With the use of the SAFE™ Solution, the project was completed during the months of June and July and required only 2 HICs at the 85% fill level. These dewatered HICs were then clear for DOT transport and were shipped to the Clive, Utah Energy Solutions Site for final disposal.

SAFE™ TECHNOLOGY UTILIZING ELECTROCOAGULATION (EC)

The Energy Solutions SAFE™ electrocoagulation (EC) process is the heart of the system and works on an electricity-based technology supplying a direct current to radioactive wastewaters via specially designed flow-through electrodes. This is a low voltage, low amperage, low pressure and ambient technology especially designed for minimizing resulting waste volumes for disposal and personnel doses (thus achieving ALARA goals). The original projection for the project was 13R and the actual was just under 3R. As wastewaters, contaminated by radionuclides, heavy metals, colloids, clay/dirt, surfactants/cleaners, oil and greases, biologicals, etc., are passed through the EC cell(s), four treatment reactions occur, which are integral to this process:

Coagulation- As contaminated water passes through the cell assembly DC power is applied, or pulsed, to the cell. Metallic ions from the cell electrodes slough off and provide bridging seeds to the suspended solids present. Only as much counter material is supplied as there are solids present, thus controlling the solids addition. Colloids remain suspended indefinitely in solution due to their similar charge. Thus, they repel each other and do not allow coagulation or floccing. These metallic ions cause the charge of the suspended solids, or colloids, oils and greases, etc. to be neutralized, or destabilized. This charge neutralization causes contaminants to begin to coagulate, or floc, and become large enough to settle or be filtered by standard filtration, UF or RO, electromagnetic filtration (EMF), or High Gradient Magnetic Separation (HGMS) filtration. This EC process does not require the addition of chemicals with the exception of adjusting the pH or conductivity, if required.

Oxidation- As wastewater, contaminated by heavy metals, radionuclides, etc., is passed through the cell(s), metals are reduced to an oxide. Metal oxides are changed from a dissolved state to a suspended state and are precipitated from the water. Heavy metals that are oxidized by passing through such a process, generally pass a Toxicity Characteristic Leaching Procedure (EPA TCLP test), which provides significant savings for the cost of sludge disposal.

Aeration- A natural byproduct of the EC Process is aeration. No air or any other gases are injected into the process, as the dissociation (hydrolysis) products of water supply tiny bubbles giving the coagulated contaminants buoyancy. In such a way, oils and greases and other lighter sludges can either be skimmed off, or re-mixed and settled with the rest of the sludge.

Biologicals- A further advantage of the EC Process is that it is a natural biocidal process. This occurs by rupturing “bugs” by electro-osmotic shock.

The presence of iron (iron oxide from carbon steel piping) and other total suspended solids (TSS) colloidal buildup in Boiling Water Reactor (BWR) circuits and wastewaters is decades old. In, perhaps the last decade, the advent of pre-coatless filters for condensate blow down has compounded this problem due to the lack of a solid substrate (e.g., powdex resin pre-coat) to help drop the iron out of solution. The presence and buildup of this iron in condensate phase separators (CPS) further confounds the problem when the tank is decanted back to the plant. Iron carryover here is unavoidable without further treatment steps. The form of iron in these tanks, which partially settles and is pumped to a de-waterable high integrity container (HIC), is particularly difficult and time consuming to dewater (low shear strength, high water content). The addition upstream from the condensate phase separator (CPS) of chemicals, such as polymers, to carry out the iron, only produces an iron form even more difficult to filter and dewater (even less shear strength, higher water content, and a gel/slime consistency).

Typical, untreated colloidal material contains both sub-micron particles up to, let's say 100 micron. It is believed that the sub-micron particles penetrate filters, or sheet filters, thus plugging the pores for what should have been the successful filtration of the larger micron particles.

Like BWR iron wastewaters, fuel pools/storage basins (especially in the decon phase) often contain colloids which make clarity and the resulting visibility nearly impossible. Likewise, miscellaneous, often high conductivity, wastestreams at various plants contain such colloids, iron, salts (sometimes seawater intrusion and referred to as Salt Water Collection Tanks), dirt/clay, surfactants, waxes, chelants, etc. Such wastestreams are not ideally suited for standard dead-end (cartridges) or cross-flow filtration (UF/RO) followed even by demineralizers. Filter and bed plugging are almost assured.

The key to solving these dilemmas is 1) to break the colloid (i.e., break the outer radius repulsive charges of the similar charged colloidal particles), 2) allow these particles to now flocculate (floc), and 3) form a type of floc that is more readily filterable, and, thus, de-waterable (high shear strength and low water content). This task has been carried out with the innovative application of electronically seeding the feed stream with the metal of choice, and without the addition of chemicals common to ferri-floccing, or polymer addition. This patent-pending new system and technique is called Seeding And Filtration Electronically, or the SAFE™ Solution.

Once the colloid has been broken and floccing has begun, removal of the resultant floc can be carried out by standard, backwashable (or, in simple cases, dead-end) filters; or simply in dewaterable HICs or liners. Such applications include low level radwaste (LLW) from both PWRs and BWRs, fuel pools, storage basins, salt water collection tanks, etc. For the removal of magnetic materials, such as some BWR irons, an ElectroMagnetic Filter (EMF) was developed to couple with the ElectroCoagulation (EC), (or metal-floccing) unit operation. In the advent that the wastestream primarily contains magnetic materials (e.g., boiler condensates and magnetite, and hemagnetite from BWRs), the material can be simply filtered using the EMF.

Bench-, pilot- and full-scale systems have been assembled and applied on actual plant waste samples and wastestreams quite successfully. The effects of initial feed pH and conductivity, as well as flocculation retention times were examined prior to applying the production equipment into the field. Since the initial introduction (Denton, et al, EPRI, 2006), the ultimate success of field applications is now being demonstrated as the next development phase worldwide with NPP clients, such as Exelon Corp., that realize the potential of the innovative approach. For such portable field demonstrations and demand systems, a fully self-enclosed (secondary containment) EC system was developed and assembled in a modified B 25 Box (Floc-In-A-Box) to be deployed at a number of NPP sites. A similarly self-contained, full-scale (30 gpm) Sealand has been designed for deployment at the Eurex Processing Plant pool cleanup project in Sogin, Italy. This paper will concentrate on the development and results of a full-scale SAFE™ System deployed at Exelon's Dresden NPP as a vault cleanup demand system. This is a 30 gpm EC system to convert vault solids/sludges to a form capable of settling and being collected and dewatered in High Integrity Containers (HIC). This initial vault cleanup work had a duration of approximately three months, prior to demobilization.

ANTICIPATED PLANT CONDITIONS, ACTUAL PLANT CONDITIONS & BACKGROUND

Realizing that the waste was poorly characterized, doses somewhat uncertain, and sludge volumes merely estimated, flexibility was built into the approach as was equipment for cleaning out this demineralizer vault containing legacy sludges stored for some six years while investigating a successful approach. This included the larger processing flow rate of 30 gpm, potential for pH and conductivity addition by a Chem-Add Skid, removable EC Skid with both production and recycle valving, quick plug-and-play replacement EC Cells, optional HIC dewatering backup (Press-Pak feature), and totally remote (segregated) operational controls.

The sludge was estimated to be about 2-3 feet in depth with 5-6 feet of supernatant on the surface to be used for slurring and mobilizing the sludge. From best estimates from the plant, the source was thought to be from concentrated waste (CW) at ~7-8 R/Hr on contact, with a conductivity of ~ 90 micromho/cm, and pH of ~8.8. As mentioned, a previous attempt at cleaning out the vault had been attempted by wanding the material out of the vault manually and dewatering in a High Integrity Container (HIC). This attempt was terminated due to the high dose to personnel and the almost instant plugging of filters by the tacky and extremely fine material.

The original planning estimate of 1 to 1.5 weight % slurry was found to be approximately 15-20 wt. % routinely and spiked over 30 wt. % on some samples. The higher than anticipated solids content was confounded by an inadvertent supernate discharge by a sump pump activated prior to commencing operations. While not an ideal situation for any water treatment process, where high solids fouling and plugging could occur, the system was still able to handle and process the material.

An additional challenge was later encountered when an unknown source of in-leakage was found to be filling the vault by several feet a day. This in-leakage was thought to be coming from pipes to the demineralizer vessel and resulted in a much higher conductivity (2500-3000 micromho/cm) and lower pH (brought the overall pH down to ~7.6) than expected. The higher than anticipated conductivity (>2500 vs 90 micromho) and lower pH (7.6 vs 8.8) allowed a lower addition of alum by the Chem-Add System to the optimum operational range of pH 6.5-7.0. The SAFE™ System was able to process this additional volume while simultaneously processing the slurried sludge.

EQUIPMENT DESIGN AND FABRICATION

The flexibility built into the equipment skids mentioned earlier can be seen during the fabrication and assembly at our facility located in Seattle, WA. Since this application suggested actually lowering the EC Cell Skid itself down into the sludge in a remote, high dose vault, a light-weight, disposable skid with stilt-like legs was designed and fabricated. Figure 1 shows the fabrication of this elevated cell design. While Figure 2 shows the internal complexities of the remote control panel. All operations in the SAFETM System are controlled by this panel including pH, conductivity, voltage and amperage set points, valve positions, low flow or over voltage shut downs and electrode-scaling protection.

The fabrication and assembly of the EC Skid, Control Panel and Chem.-Add portion of the system required 8 weeks prior to shipment for finally balance of plant testing at the Columbia Maintenance Facility in Columbia, SC. The supporting pumps, HICs and transformer were assembled with the final system within another two weeks for final mobilization at the site.



Figure 2. Remote Control Panel



Figure 1. EC Cell Skid (5 gpm each)

EQUIPMENT MOBILIZATION

As mentioned previously, the vault floor being some 30 feet below the operating surface (two elevations below) and containing a 10 foot-diameter demineralizer vessel in the middle of the vault (with sludge accumulation below it), access was particularly challenging and operational space limited. Fortunately, a fully-operational truck bay was located on the second level for placement of the low-boy trailer, cask, HIC, and dewatering head and pump skid. Since all SAFETM Solution systems are designed to be totally segregated as to hot and cold components, only the EC Cell Skid itself and associated valving (~ 600 lbs. due to the aluminum skid frame construction), two Grindex chopper pumps, and Grindex feed pump had to actually be lowered into the vault and connected via camlok hoses (Figure 3). All other equipment and controls were located on the second level above and operated totally remotely. The Grindex chopper and feed pump controls (VFDs) were placed, along with the Chem-Add System, at the upper railing location (Figure 4). The EC control panel and remote camera monitor was placed some 8-10 feet farther back from the rail (Figure 5). The dewatering pump skid was another 20 feet from the panel while the cask and trailer were at the farthest location, ~30-40 feet, from the control area (Figure 6). It took several weeks to put all equipment in place and thoroughly check out the system prior to operation. Once placed in this manor, however, it was found to function optimally.



Figure 3. EC Cell Skid lowered into place in demineralizer vault



Figure 4. Chem-Add System with alum addition drum and control panel mounted feed pumps



Figure 5. EC Control Panel and Chem-Feed and Grinder Pump VFD Panels



Figure 6. Cask-mounted trailer with HIC and Dewatering Head and Pump Skid

OPERATIONS AND FINDINGS

Electro-coagulation (EC) is a technique that facilitates rapid destabilization and flocculation of colloidal suspensions to cause the suspended solids to separate from slurry phase. It is generally accepted that coagulation is brought about primarily by the reduction of the net surface charge to a point where the colloidal particles, previously stabilized by electrostatic repulsion, can approach closely enough for van der Waal's forces to hold them together and allow aggregation. In the EC process, the coagulant is generated in situ by electrolytic oxidation of an appropriate anode material (aluminum in this case). The reduction of the surface charge is a consequence of the decrease of the repulsive potential of the electrical double layer by the presence of an electrolyte having opposite charge.

In this process, charged ionic species, metals or otherwise, and suspended solids are removed from wastewater by allowing them to interact with an ion having opposite charge, or with floc of metallic hydroxides generated electrochemically within the effluent. Typically, no supplementary organic polymer coagulant addition is required.

In the EC process, the coagulant is generated in situ by electrolytic oxidation of an appropriate anode material (generally iron, aluminum or titanium). In this process, charged ionic species - metals or otherwise - are removed from wastewater by allowing it to react with an ion having opposite charge, or with floc of metallic hydroxides generated within the effluent.

The EC technology, thus, offers an alternative to the use of metal salts or polymers and poly-electrolyte addition for breaking stable emulsions and suspensions. The technology removes metals, colloidal solids and particles, and soluble inorganic pollutants from aqueous media by introducing highly charged polymeric metal hydroxide species. These species neutralize the electrostatic charges on suspended solids and oil droplets to facilitate agglomeration or coagulation and resultant separation from the aqueous phase. The treatment also prompts the precipitation of certain metals and salts. The specific advantages of the EC technology, observed in this application, are discussed in the Summary and Conclusions section.

Preliminary batch EC runs were performed prior to full-scale operation with use of a small canister unit fitted with aluminum electrodes (Figure 7). The flocculated solids were found to be initially buoyant, due to their association with small gas bubbles (electrolysis of water) produced by the electrode reaction. The quantities of gas produced during operation of an EC treatment unit (even full scale) are very small, and do not present a safety concern for a work area with normal ventilation (EPA report 540R96502).

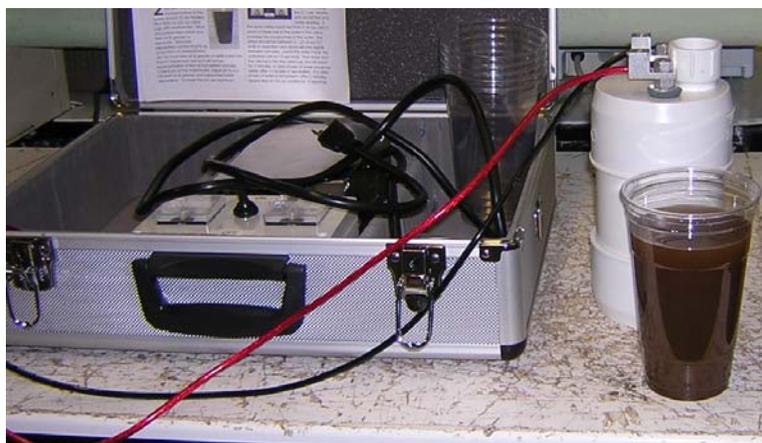


Figure 7. Canister EC demonstration unit, shown with an iron suspended solid slurry.

The practical application of EC depends upon electrical coupling between the solution and the electrodes. Electrical coupling and anode dissolution are increased with greater electrode area contacted by the liquid (volume or depth), greater conductivity of the liquid being treated, and the total time that the current is applied (Figure 8).

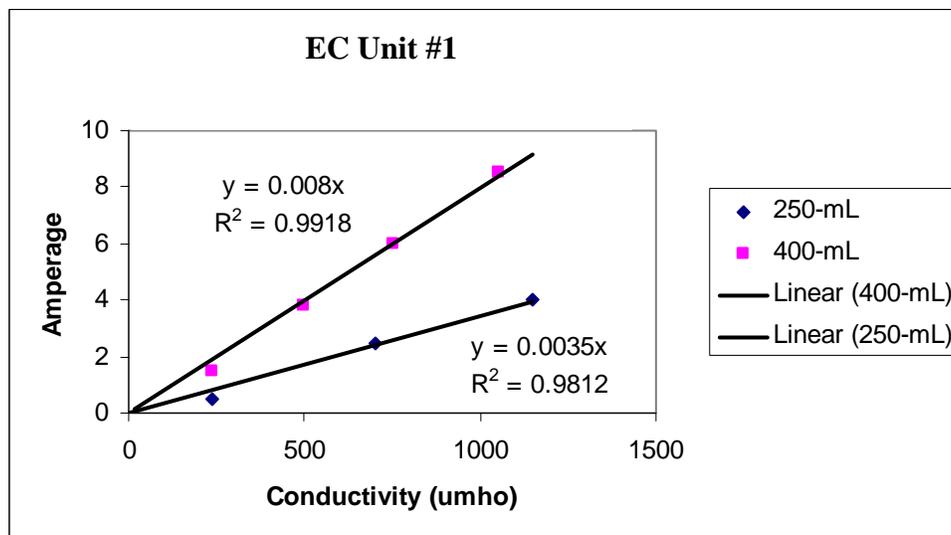


Figure 8. Effect of solution volume (depth of liquid, hence surface area of electrode contacted) and conductivity (μmhos) on the electrode amperage in an EC demonstration canister.

For effective EC with the demonstration unit, the applied current flux should be ≥ 1 amp-min. For low conductivity BWR water samples, this implies a longer EC pulse time (e.g., ≥ 2 -min) or the addition of an innocuous salt (e.g., alum, Na_2SO_4 or NaHCO_3) to raise the water conductivity so that a shorter applied current pulse time can be used to generate an equivalent amount of flocculent. The actual mass of flocculent produced under these conditions is very low. The mass-median particle size of the flocculent produced is ~ 20 - μm (as estimated by light scatter measurement on vigorously stirred slurry with use of Microtrac instrumentation); the flocculent agglomerates further in quiescent liquid. For waste containing colloidal solids, the flocculent helps to bridge the particles so that they settle more readily. The flocculent may also sorb soluble ionic contaminants.

Figures 9-12 show the effect of EC treatment of typical BWR slurries. Figure 9 shows aliquots of slurry before EC. EC was performed on one aliquot at a current flux of ~ 1 amp-min; Figure 10 illustrates the decanted EC-treated slurry after ~ 1 -min of quiescent phase separation. A large portion of the destabilized suspended solids after EC treatment initially rise to the air interface, due to their association with electrolysis gas bubbles. Figure 11 illustrates the same sample aliquots 30-min after EC treatment; essentially none of the colloidal solids in the untreated slurry have sedimented.

In Figure 12, aliquots of untreated slurry (left) and EC-treated (right) are filtered through Whatman 41 paper (with nominal retention of particles > 20 - to 25 - μm). A significant fraction of the solids in the untreated sample pass through the coarse filter, eventually blocking flow. Whereas the EC-treated slurry is readily filtered. This demonstrates that EC alone effects significant particle flocculation.



Figure 9. Samples of suspended slurry, before electrocoagulation (EC) testing



Figure 10. Sample EC (right) represents electro-coagulation for ~ 1 amp-min, followed by ~ 1-min quiescent settling.



Figure 11. Sample EC (right) represents electro-coagulation for ~ 1 amp-min, followed by ~ 30-min quiescent settling. The untreated sample (left) shows minimal settling during this time interval.



Figure 12. Filtration of raw sample (left, filter plugged) and EC-treated sample (right). Both samples were mixed well before filtration with Whatman 41 paper (nominal retention of particles > 20- to 25- μm , which emulates standard sheet filters).

In summary, electro-coagulation (EC) destabilizes colloidal suspended solids in BWR waste water, and effects particle flocculation. This makes subsequent solids removal much easier, as illustrated in Figure 12. Additional polymer flocculent may be added to yield even larger agglomerates, but this generally is not necessary. When very low conductivity waste water (such as BWR slurry) is treated, it may be necessary to recycle fluid through the EC electrode assembly to increase the current flux so that enough flocculent is produced ($\text{Al}(\text{OH})_3$, in the case of aluminum electrodes). Alternately, the conductivity of the fluid can be increased by the addition of small concentrations of innocuous (non-toxic) salt [such as sodium chloride, sodium bicarbonate, or alum,(sodium sulfate)].

Once the product samples in the actual vault were determined to be adequately flocced by EC and the 20-25 micron floc was found to readily settle and successfully dewater in a portable vacuum assembly (i.e., the tackiness and fineness had been overcome), the recycle valve was closed and the product valve opened and the product slurry was pumped up to the trailer-mounted fill head and into the HIC in campaigns.

DEMOBILIZATION

Due to the specialized design of the SAFE™ System, demobilization and disposal of the waste and equipment was greatly simplified. As mentioned, the vault produced only 2 HICs for shipment to Clive. The only contaminated portion of the remaining system was the EC Skid itself and 3 Grindex Pumps. The remaining system including the Control Panel, Chem-Add Skid and Pump Controls was returned to our licensed facility for future use as a demand system.

SUMMARY AND CONCLUSIONS

Electro-coagulation (EC) is a technique that facilitates rapid destabilization and flocculation of colloidal suspensions to cause the suspended solids to separate from slurry phase. It is generally accepted that coagulation is brought about primarily by the reduction of the net surface charge to a point where the colloidal particles, previously stabilized by electrostatic repulsion, can approach closely enough for van der Waal's forces to hold them together and allow aggregation. In the EC process, the coagulant is generated in situ by electrolytic oxidation of an appropriate anode material (aluminum in this case). In this process, charged ionic species, metals or otherwise, and suspended solids are removed from wastewater by allowing them to interact with an ion having opposite charge, or with floc of metallic hydroxides generated electrochemically within the effluent. Typically, no supplementary organic polymer coagulant addition is required.

Thus, electro-coagulation (EC) was found to be an attractive treatment option to rapidly destabilize the colloidal particulate phase, allowing more facile particulate removal by decantation and/or coarse filtration. However, the liquid medium must have some conductivity ($\geq 100 \mu\text{mho}$ is preferred), in order to allow effective electrical coupling with the EC electrodes. A very small amount of aluminum or sodium sulfate salts can be added to the feed slurry, adjusting the water quality parameters to a conductivity of $\geq 100 \mu\text{mho}$ and a pH value near 6.0-7.0. The EC-treated vault slurry had a pH value near 6.5 (within the pH range for minimal solubility of amphoteric aluminum hydroxide).

In contrast to untreated wastewater, the agglomerated particles in the EC-treated aliquot could be filtered relatively rapidly, yielding a clear filtrate, indicating that the flocs that have been formed are now $> 20\text{-}\mu\text{m}$ in size, are pumpable (high shear strength), and filterable/dewaterable with ease (low water content). Final waste volumes also show that the actual volumetric fraction of solids produced are relatively small.

In order to estimate the amount of material (Al or Fe depending on the electrode material) added by the EC process, a rough rule of thumb has been found to be ~15 ppm per amp-minute. It was found with most wastewaters that Cs seeding (if that step is required) added ~ 100 ppm Cs Seed and 10-15 ppm/amp-minute additional floc from the electrodes. In a typical BWR wastewater case, where the TSS represented ≤ 0.15 wt% (~ 1500 ppm). At 1.5 amp-min., the Al (III) added by the EC process would be ~ 20ppm, or ~ 60 ppm as Al(OH)₃. It was found the relatively low floc [~ 40 ppm as dried Al(OH)₃] worked quite well for the high colloid level present (~1500 ppm), and would be even more enhanced with the use of recycle. Even at that relatively low treatment dose, the colloidal TSS in the wastewater was effectively flocculated to yield agglomerates that were easily filtered and dewatered.

Another rule of thumb is that, empirically, TDS (in mg/l) is typically ~0.5 X conductivity (in umho/cm). For instance, a conductivity reading of 100 umho/cm corresponds to about 50 ppm of TDS. As can be seen, the amount of material actually added in this vault cleanup of ~15 ppm per amp-min compared to the existing ~1500 ppm of TDS present (0.5 X conductivity of 3000 micromho/cm) is minimal.

In this vault cleanup, as a precautionary measure, the HIC was a specially designed Press-Pak with internal sheet filters, final dewatering leg, and an expandable, outer bladder if needed for final dewatering. It was found after filling the first HIC, of two, that the material dewatered and passed final dewatering tests without the need for the precautionary Press-Pak feature.

Original estimates by the evaluation team estimated it would take some 11 to 12 HICs to remove the vault contents to a remote location for treatment, dewatering and final shipment. With the use of the SAFE™ Solution, the project was completed during the months of June and July and required only 2 HICs at the 85% fill level. These dewatered HICs were then clear for DOT transport and were shipped to the Clive, Utah Energy Solutions Site for final disposal.

During the past year, additional refinements to the patented SAFE™ Solution have included the **SAFER™** System (**S**calant and **F**oulant **E**lectronic **R**emoval) for the removal by EC of silica, calcium and magnesium. This has proven to be an effective enabler for RO, NF and UF as a pretreatment system. Advantages here include smaller, more efficiently designed systems and allowed lower removal efficiencies with the removal of the limiting factor of scalants. The **SAFEST™** System (**S**AFE **S**ynergistic **T**echnology) further enables RO systems by utilizing the brine RO reject to supply conductivity to the EC process, while, not only removing scalants, but minimizing brine normally going to further processing such as spent condensate resins or thermal treatment.

Similarly, the SAFE™ System has been applied in the form of a **BAC-UP™** System (**B**oric **A**cid **C**lean-**U**p) as an alternative to more complex RO or boric acid recycle systems.

Lastly, wastewaters have been treated from different DOE sites and fuel reprocessing plants for the removal of totally soluble, TDS, species (e.g., Cs, Sr, Tc, Am, Pu, etc.). For these applications, an ion-specific seed (an element of the **SMART™** System) was coupled with the soluble species prior to EC and subsequent filtration and dewatering, for the effective removal of the high-level complex and the segregation of low level and high level wastestreams (LLW & HLW). This will become of paramount importance as Class B and C disposal sites are closed in the near future and maximizing Class A waste for disposal and minimizing > Class C waste volumes for storage become the prevailing goals.

Overall, the Dresden Project Manager and Corporate Radwaste Manager of the demineralizer vault cleanup project, were quite pleased with the ALARA approach, personnel dose levels, easily dewaterable product, and low waste volumes achieved. So much so, they are nominating the project and technology for the 2008 Top Industry Practices (TIP) Award. Subsequent vaults are now being looked at for future treatment, retrieval, shipment and disposal.