Looking to the STARS to Reduce Class B/C Waste

EPRI's Waste Logic–Solid Waste Manager Can Help

By Clint Miller

The Strategic Teaming and Resource Sharing (STARS) alliance includes six pressurized water reactor (PWR) stations, all located west of the Mississippi River: Callaway, Comanche Peak, Diablo Canyon, Palo Verde, South Texas Project (STP), and Wolf Creek (Palo Verde joined in 2002).

In 2000, a STARS radwaste team was formed to pursue cost reductions. The team was challenged to obtain a 10 percent savings in radwaste costs. That year, radwaste team members from the original five STARS plants met to discuss joint contracting of radwaste services. They decided to pursue savings in offsite waste processing services first, because this would be quick to implement and would have the least impact on plant practices. They also decided to team with USA plants (another plant alliance) to increase the size of the pool and to better leverage purchasing power.

The STARS team issued an offsite waste processing bid and received several proposals. The bid review resulted in awarding a contract to a waste processor for Class A dry active waste (DAW) processing and for clearance survey services with quantity discounts based on the total mass shipped to that processor.

The STARS team members reported back to management that because DAW processing costs were only about 25 percent of the total radwaste contract costs, they should expect only a proportionate savings. For example, the Diablo Canyon radwaste savings goal from STARS was pegged at $100 000, which is 10 percent of the typical annual contract cost of $1 million. Because DAW accounts for only 25 percent of total radwaste service costs, the savings goal from the joint contract for Diablo Canyon was set at $25 000. The USA and STARS alliance held together over the term of the contract, and quantity discounts were awarded. Although the savings goal appeared very challenging, Diablo Canyon actually achieved savings of $24 000 in 2000, all

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due to the joint contract.

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A separate contract was awarded for offsite processing of spent resin including Class B/C waste. This contract also included quantity discounts based on the total volume shipped to that processor. Although savings were obtained from this joint contract, these savings did not approach those desired (e.g., $75 000 for Diablo Canyon). As was discovered by the industry when dealing with DAW, pitting processors against disposal sites can bring some savings, but large savings come about only with waste minimization efforts. It was clear that STARS plants needed wet waste reduction efforts.

Waste Reduction Efforts

In 2001, the STARS plants held several telephone discussions about Class B/C waste reduction efforts. One thing was clear: Diablo Canyon has the longest shipping distance of Class B/C waste in the United States. Since the early 1990s, Diablo Canyon has had to ship Class B/C waste to Barnwell, S.C. The associated high shipping costs have imposed a greater incentive for Diablo Canyon to reduce Class B/C wet waste generation than for other power plants.

Wet waste reduction efforts at Diablo Canyon began with the liquid radwaste treatment system. As at most PWR plants, the use of selective ion exchange and segregated cation and anion resin beds resulted in dramatic improvements. Use of a cesium-selective bed enabled the life of cation resin to be extended for the removal of other nuclides. Using segregated cation and anion beds, as opposed to mixed beds, enabled the full capacity of the resin to be consumed, extending bed life and thus reducing waste generation. In addition, this segregation of cation from anion resin reduced the disposal cost of anion resin because spent anion resin is low in dose rate and curie content. However, this required segregated packaging of the spent resin, which resulted in additional resin transfers and separate packaging shields.

The high costs for wet waste shipping and disposal drove Diablo Canyon to extend their wet waste reduction practices from the liquid radwaste system to other radioactive liquid treatment systems. These included the spent fuel pool (SFP), chemical volume control system (CVCS), and the boron recycle system. Where single-vessel mixed beds were provided for SFP and CVCS cleanup, higher cation-to-anion resin loads were used. Diablo Canyon also found that alternate cation resin (i.e., Dow XFS instead of Rohm & Haas IRN-77) had a longer life in SFP, CVCS, and boron recycle systems.[1] A Final Safety Analysis Report (FSAR) change was issued for the boron recycle system allowing an anion bed rather than a mixed bed to be loaded in the vessel downstream of the cation bed.

Discussions between Diablo Canyon and Comanche Peak determined that only three beds were Class B/C: the CVCS lithiated mixed bed, the CVCS shutdown cleanup mixed bed, and the SFP bed. Discussions with STP identified that they had several other spent beds that were Class B/C, due to the presence of ^{63}Ni. Callaway indicated that the presence of ^{137}Cs from fuel defects resulted in more than just three of their vessels becoming Class B/C. Both STP and Diablo Canyon had noted peroxide generation in the SFP was shortening the life of SFP resin beds. STP was using a new cation resin to extend the life of these beds.[2] Diablo Canyon was interested in using this resin for SFP and CVCS service based on the STP results.

Because many of the what-if scenarios were already being implemented successfully at other STARS plants, their cost savings history served as a sanity check on the potential cost savings other STARS plants could obtain.

Although Comanche Peak, Diablo Canyon, and STP had similar length fuel cycles, the size of the vessels for Diablo Canyon was half those of the other plants. In some cases, the smaller beds at Diablo Canyon were serving as long as larger beds at other plants. Callaway and Wolf Creek, as single-unit stations, had only one spent resin storage tank, while the other stations had at least two.

Packaging for Class B/C spent filters also varied across the STARS fleet. Diablo Canyon was the second station in the United States to obtain a shielded filter shear to conduct onsite volume reduction of filters. Using this shear reduced Diablo Canyon filter liner shipments from two per year down to one every two years, a 4-to-1 volume reduction. In this case, the shear paid for itself in its first year of use. Callaway and Wolf Creek had shared a filter shear. Subsequently, Wolf Creek's use of the shear was suspended because of efforts to reduce radiation exposure. Comanche Peak had just obtained a filter shear, while STP had no shear.

Through these discussions, it became clear that adopting the best practices from each other would not be a simple task because of the different design features at the stations. In the past, several plants had suggested changes to reduce wet waste generation but were unable to justify a design change, an evaluation, or a procurement action, which was necessary to adopt each change. The team decided that an outside assessment for wet waste reduction would be helpful.

At the end of 2001, the Electric Power Research Institute (EPRI) conducted a "desk top" corporate assessment for STARS on the joint DAW processing contract using Waste Logic–Solid Waste Manager. The team was pleased with the results of this assessment of the STARS fleet.

EPRI Assessment

The STARS team contacted the EPRI about conducting a Class B/C waste reduction assessment of STARS. EPRI was interested in pursuing this, since available disposal and storage of Class B/C waste is an industry issue. They also thought that this assessment might contribute to an upcoming EPRI report on Advanced Strategies and Waste Streams for Extended LLW Storage.

To begin this wet waste reduction assessment, the EPRI contractor conducted a survey to determine the current waste generation. The contractor developed a spreadsheet so that each plant could indicate by vessel the type of resin loaded, the bed life, and the typical resulting waste class. In addition, the contractor requested information on the number of Class B/C and Class A filters generated per year. The data was collected from four of the STARS plants in 2002. Two of the stations were visited to collect the data, while two provided the data over the telephone and by e-mail.

Wet waste reduction efforts require support from departments, sections, and groups other than radiation protection. Chemistry, operations, system engineering, and design engineering support may all be required to implement a wet waste reduction practice.

The EPRI contractor obtained several wet waste reduction practices and plans from the four STARS stations. Some of the cases involved different ways to package Class B/C resin separately from Class A resin. Some involved plans to extend the life or reduce the volume of Class B/C resin beds. Although this project was focused on Class B/C reduction, some of these plans included the reduction of Class A resin. Plants also provided information from which to derive the disposal cost savings to segregate spent filters or volume-reduce spent filters.

In addition to the practices and plans plants developed on their own, cases from other plants were evaluated. After obtaining input from the four plants, the contractor had developed a comprehensive list of "what-if" cases for PWRs. The potential cost savings for each scenario were generated using Waste Logic–Solid Waste Manager. Since many of the what-if scenarios were already being implemented successfully at other STARS plants, their cost savings history served as a sanity check on the potential cost savings other STARS plants could obtain.

The cost to implement a particular practice was not estimated as part of the EPRI assessment. The purpose of calculating the potential cost savings was to quantify the *possible* annual savings, not determine the payback period for any particular practice at a given plant. With the potential cost savings, for each practice derived, each plant's radwaste manager could determine which practices to pursue first. In addition, the dollar figures are now readily available to prepare justifications for practices that will require a design change, an evaluation, or the procurement of a component or tool.

The EPRI contractor produced an interim report to summarize the assessment across the four plants with a separate section for each plant. The plant-specific sections listed the cases that were run and the associated disposal cost savings. The cases were organized into three groups: cases that dealt with the segregation and packaging of spent resin, cases that involved the reduction of spent resin generation, and cases involving the segregation and packaging of spent filters. When a plant had already implemented a practice, the associated dollar savings was reported and highlighted as a benefit already being received.

PWR Wet Waste Reduction

The list of cases or what-if scenarios to be evaluated at a PWR for wet waste reduction are as follows:

- Collect Class B/C resin beds needing a Type B cask in a spent resin storage tank for decay. There should be only three beds (CVCS lithium mixed bed, CVCS shutdown bed, and SFP).
- Other beds should not be mixed with the aforementioned batch. This may require a bypass line if only one spent resin storage tank exists. These batches can be shipped in an IP-2/Type A cask. Type B Class B/C resin would go to the storage tank, while other resin beds would bypass the tank and be routed directly to a high-integrity container (HIC).
- Class A spent resin should be packaged separately from Class B/C to guarantee disposal at Envirocare. This may require an additional packaging shield.
- Avoid mixed beds whenever possible. This may require

an FSAR or design document change to allow alternate vessel loading.

- Extend the life of SFP beds. Plants could increase the cation-to-anion ratio, use alternate resin, short load the vessel, or align the vessel only when needed to lower pool dose rates.
- Shutdown bed: A 30-cubic-foot bed can clean up a reactor shutdown. If vessels are larger, short load the vessel or use the bed for two shutdowns. Plants might need to alter resin type and/or cation-to-anion ratio.
- Extend lithiated mixed bed life. Ten cubic feet of lithiated cation resin can support a fuel cycle. Short load the vessel with 10 ft^3 of lithiated cation (now available) and 5 ft^3 of anion. For larger vessels, reduce the volume of anion resin and use the bed for two cycles.
- Consider a cesium-selective filter to protect other cation beds from becoming Class B.

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- Deboration: Make the boron thermal recovery system (BTRS) work to extend resin life indefinitely (10–15 years).
- Consider volume reduction of Class B/C filters.
- Segregate high-dose Class A filters from B/C filters. This may require a shielded container to ship Class A filters to waste processors for compaction and disposal at Envirocare. Cement encapsulation of higher activity Class A filters for disposal at the Envirocare Containerized Waste Facility could be used until a super cassion is approved.

Tasks Completed by STARS Plants

Each of the four STARS plants reviewed results from the assessment report. The status of implementing various changes at each plant is as follows:

Diablo Canyon

Diablo Canyon had already implemented the segregated packaging of spent resin. Diablo Canyon has two spent resin storage tanks, two large packaging shields (one for low- and one for medium-activity resin), and a railcar for high-activity resin. The EPRI assessment revealed that this segregation practice was already saving $310 000 annually. Class A filters less than 150 milliroentgens per hour have been compacted onsite, placed in drums, and sent to waste processors for super compaction and disposal at Envirocare. All other filters have been placed in encapsulation liners for burial at Barnwell.

Diablo Canyon developed an action plan to reduce the generation of Class B/C resin and to alter the packaging of higher dose rate Class A filters. All actions were completed in 2002. The shutdown beds at Diablo Canyon had to be increased in size from 30 ft^3 to 39 ft^3 to support zinc addition.[3] After three cycles using the large bed, Diablo Canyon returned to the use of the 30-ft^3 bed in 2002. This reduction will result in a savings of $37 000 per year starting in 2004. The type of cation resin loaded into the SFP vessel was changed to IRN-99 following the lead of STP. It is estimated that using this resin and limiting the alignment time of the bed will increase the bed life from one year to two for a savings of $13 500 per year starting in 2004. The lithiated mixed bed vessel was short loaded with 10 ft^3 of the new IRN-318 lithiated cation and 5 ft^3 of anion resin. This reduction is estimated to save $38 000 per year starting in 2004. These changes required only approval by Chemistry and a procedure change at Diablo Canyon.

Class A filters that exceed 150 mR/h up to 400 mR/h are no longer placed in filter liners with Class C filters for disposal at Barnwell. A B-25 box lined with lead sheet was constructed as a conveyance for higher dose rate Class A filters. Such filters are now placed into a bag with the filter ID on the bag and loaded into the shielded box. These filters will be shipped to a waste processor for packaging and disposal at Envirocare.

By implementing these waste reduction actions, Diablo Canyon will exceed the desired savings of $75 000 per year for wet waste.

South Texas Project

The STP has pursued a huge project in 2002 and 2003 to empty their resin storage tanks so they could begin to package Class A resin separately from Class B/C resin. Segregated packaging began last year, and already a HIC with only Class A resin and carbon was shipped this year. STP is looking at the idea of running beds to exhaustion instead of dumping them on a schedule of when operators are available.

The IRN-170 stochiometric mixed bed resin with higher capacity cation resin has been loaded in the SFP vessels at STP. Although this resin is more impervious to peroxide attack than before, peroxide is still limiting the life of these beds. STP is placing the SFP beds in service only when needed, not 24/7, to extend resin life to two years. STP has also switched to the IRN-317 stochiometric lithiated mixed bed resin with higher capacity cation resin in order to extend bed life. STP used their 75-ft^3 mixed bed for two crud burst cleanups instead of just one, reducing this cost by half.

The STP is considering using cesium-specific filter cartridges. These cartridges could allow recycle holdup tank liquid to be discharged without further treatment. This would reduce the generation of liquid radwaste media. STP has been able to make their BTRS function four times to support reactor coast down without the need to replace any resin. This results in a very large reduction of Class A resin and the associated costs.

Comanche Peak

Comanche Peak has been segregating Class B/C resin packaging from Class A resin. Class A resin is sent to Studsvik and the residue buried at Envirocare. This segregation and associated lower disposal cost results in an estimated $164 000 annual recurring cost savings. Comanche Peak is looking at reducing the size of the shutdown cleanup bed. The BTRS vessel used to hold the crud burst bed is 70 ft^3. The resin load was to be reduced by 10 ft^3 for the fall 2003 outage and if successful, by another 10 ft^3 the following cycle. A 20-ft^3 reduction per outage translates to an annual cost savings of $35 000.

Segregation of cation from anion resin reduced the disposal cost of anion resin because spent anion resin is low in dose rate and curie content.

Another recommendation being followed by Comanche Peak is changing the boron recycle system feed beds from two 30-ft^3 mixed beds to a cation bed followed by an anion bed. Currently, all the resin from these mixed beds are disposed of as Class B/C waste. The change to a cation and anion bed in series will allow for half of the resin to be disposed of as Class A. The resulting cost savings is estimated to be $6000 per year. While the savings is small, there is no significant cost or effort to achieve it, since no plant modification is required. Comanche Peak is also arranging for a cesium-selective filter like STP.

Unfortunately, Comanche Peak has recently noted increased ^{63}Ni levels in spent resin due to pH adjustment of the reactor coolant system and is currently evaluating the impact on waste classification and associated disposal cost. On the positive side, Comanche Peak procured and implemented use of a filter shear in the spring of 2002 and expects to fill its first HIC of sheared filters next year. Like Diablo Canyon, Comanche Peak estimates that the filter shear has paid for itself during the first year of use.

Callaway

Callaway has been segregating some Class A resin from Class B/C resin. This segregation and associated lower disposal cost results in an estimated $69 000 annual recurring cost savings. Callaway plans to pursue further segregation of Class A resin.

Wolf Creek

Wolf Creek has also been segregating Class A resin from Class B/C resin. Wolf Creek was the first STARS plant to send Class A resin to Studsvik, with the residue buried at Envirocare.

A Comprehensive What-If List

Waste Logic–Solid Waste Manager was able to determine potential disposal cost savings from various wet waste reduction practices. After assembling the list of possible reduction practices from four PWR plants, EPRI now has available a comprehensive what-if list for systematic assessments. Four of the STARS plants were assessed in 2002, and they are pursuing wet waste reduction efforts. The two remaining STARS plants will be assessed in 2003 and a final report issued.

Other key findings were as follows:

- Shipping Class A resin to Studsvik for processing and disposal of the residue at Envirocare as opposed to shipping resin directly to Envirocare was cost-effective for all the STARS plants except Palo Verde and Diablo Canyon.
- Cask rental rates for Comanche Peak and STP were not in line with rates at the other STARS or USA plants.

Based on these findings, only Diablo Canyon and Palo Verde have become certified waste generators at Envirocare, and the other STARS plants were saved from conducting such an effort. Meanwhile, the cask vendor has offered alternate rates for cask users in Texas.

Wet waste reduction efforts require support from departments, sections, and groups other than radiation protection. Chemistry, operations, system engineering, and design engineering support may all be required to implement a wet waste reduction practice. The disposal cost savings of a given practice is a key requirement for a radwaste reduction item to have any chance of becoming a priority for other groups. The EPRI Waste Logic–Solid Waste Manager can derive these costs savings. What STARS has found is that wet waste reduction practices can bring about significant cost savings.

References

1. K. L. James and C. C. Miller, "Full-Scale Performance of New Organic Resin Ratios and Inorganic Materials for Processing Low Level Liquids at Diablo Canyon Power Plant," Waste Management '90, Tucson, Arizona, March 1990.
2. M. F. Rejcek, "How More Means Less—The Use of a New Ion Exchange Resin," *Radwaste Solutions,* p. 10, Nov./Dec. 2002.
3. C. Miller, J. Ramirez, and E. Wessel, "Impact of Extended Fuel Cycles and Zinc Addition on Radwaste Generation from Shutdown Cleanup," 1999 EPRI International Low-Level Waste Conference, East Brunswick, New Jersey, July 1999. ■

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