A look at low-level waste, new technologies, historical reviews, dry cask storage, cost management, and regulatory initiatives.

Decommissioning and Spent Fuel Management

A report from an Embedded Topical at the 2003 ANS Annual Meeting

This year's American Nuclear Society annual meeting, held June 1–5 in San Diego, Calif., included an embedded topical meeting on Decommissioning and Spent Fuel Management, featuring sessions on low-level waste (see "Low-Level Waste Disposal in the United States—Status Update," *Radwaste Solutions,* Jul./Aug. 2003, p. 18), new technologies, historical reviews, dry cask storage, cost management, and regulatory initiatives. General chair of the meeting was Joseph Wambold, of Southern California Edison; the technical program was cochaired by Richard St. Onge and J. Mark Price, both with SCE, with the assistance of Steven Bossart, from the U.S. Department of Energy, and Donald Eggett, from Automated Engineering Services Corp.

Looking Back, Looking Forward

Workers on Their Own

In the beginning, noted Tom LaGuardia, from TLG Services Inc., when the nuclear industry began to decommission some of the early small demonstration plants from the 1950s and 1960s, regulatory guidance was nonexistent, there were no precedents from government decommissioning, and decommissioning workers were basically on their own. Despite these less than auspicious beginnings, he stated, many of the techniques developed in decommissioning these early plants are still used today. Speaking at a session on Commercial Decommissioning Historical Review, Current Status, and Future Plans, LaGuardia looked at the operating and decommissioning histories of several of these small plants, including Hallam, Piqua, BONUS, Elk River, Pathfinder, and the Sodium Reactor Experiment.

Many of the techniques developed in decommissioning the early plants are still used today.

Most of these small plants, LaGuardia said, had short operating lives, and most experienced technical or operational problems along the way. Still, they offer examples for both operational and decommissioning plants today. The Hallam plant, for example, was built primarily below grade, and, LaGuardia noted, the next generation of nuclear plants might want to look at that design in the wake of security concerns. The work done to decommission those early plants proves that decommissioning can be done safely and cost effectively, he concluded.

Millstone-1, Cool and Dim

Robert Grubb, from Transnuclear (TN), which is the integrating contractor on the Millstone-1 decommissioning, said that the boiling water reactor (BWR), shut down in November 1995, is now sort of "cool and dim," on the way to "cold and dark." Once cold and dark, the plant will sit in a SAFSTOR condition until the other two plants on the site are decommissioned in 2035, since there is no clean separation between Unit 1 and the operating Units 2 and 3. Current project goals include leaving the spent fuel in the spent fuel pool, along with the greater-than-Class-C (GTCC) waste.

When the plant is decommissioned in 2035, the reactor vessel contents

(other than the spent fuel) will have decayed so that the radioactivity readings will be below 50 000 curies (making it eligible for intact burial at Barnwell).

On work done so far at the unit, Grubb noted that some 37 nonirradiated control rod blades have been removed and shipped to Nine Mile Point; 192 contaminated blade guides have been removed and processed; 102 irradiated control rod blades have been moved into the spent fuel pool for further processing; and water clarity has been established in the reactor cavity.

The greatest problem with work at the site, Grubb said, was working around the operations of Units 2 and 3. But since they saw the problem coming, they planned for it. For example, planned outages at the operating units have priority, and the decommissioning work is scheduled around any unplanned outages. The work is currently close to being on schedule, and they hope to be done with work at Unit 1 by August 2004.

San Onofre

The San Onofre Nuclear Generating Station is another plant with both decommissioning and operating units. SCE's John Custer described some of the challenges at the plant, where, he said, operations must find ways "to get out of the way" of the decommissioning work. Problems include deconstructing around the spent fuel island (some call it a "spent fuel continent," he joked), working adjacent to operating units, and sharing a workforce.

Unit 1 is currently "cold and dark," Custer said. A minimal amount of equipment remains energized, and the energized stuff is clearly marked, he said. Decommissioning work started on the east side of the plant, where the independent spent fuel storage installation (ISFSI) will be located, and then once the spent fuel pool is empty, the work will continue to head west.

Sweden's Financing of Decommissioning

Jan Carlsson, from SKB in Sweden, described the planning and funding mechanisms for future decommissioning in that country. Sweden's nuclear power plants came on line between 1972 and 1985, and if the plants run for 40 years, plant closures will take place between 2012 and 2025. The country has no national policy requiring a certain starting point or endpoint of decommissioning, Carlsson said, allowing those decisions to be made by plant owners. A final repository will not be available until around 2045.

Under Sweden's Financing Act, plant owners pay a fee based on nuclear power production. This fee is paid into a fund that will cover future cost for spent fuel disposal as well as decommissioning and dismantling of the plants. SKB is responsible for making annual cost calculations.

Let's Share the Wealth of Experience and Data

Chris Wood, from the Electric Power Research Institute (EPRI), called for decommissioning plants to document and archive the decommissioning information and experience so future decommissioning plants do not have to reinvent the wheel later on. With the next three to four years seeing decommissioning completed at several plants, Wood said the time is right to capture the experience for the future.

EPRI's own generic planning decommissioning manual used the decommissioning plan developed for the Oyster Creek plant (when that plant was involved in a strange three-tiered planning effort to allow for continued operation, sale to another utility, or immediate shutdown; the plant ultimately was sold and is now part of the Exelon stable). EPRI has also issued a guide on license termination issues.

A related subject discussed at a different session was that of cost data. "Work fast, throw straight, and stay ahead of the hitter," said Ed Abbott, president of ABZ, noting that this is advice generally given to baseball pitchers, but that it can apply to getting cost data for decommissioning as well.

Getting the data is not easy, he conceded. Shoreham data have not been particularly useful. Good data can be obtained from plants undergoing decommissioning, he said, but you can't get your hands on it, he said. In today's competitive market, these costs are kept hidden. On the other hand, vendor data are not available to the industry as a whole, and supporting data may not be available.

Nonetheless, he said, most major decommissioning activities are the same regardless of the plant, and there are data out there on such things as person-hours expended, disposal costs, etc. Staffing costs are a substantial part of decommissioning costs, but staffing levels for each decommissioning phase are not widely available from plants undergoing decommissioning, and responses to recent staffing surveys have not been encouraging. Therefore, he said, you have to use outage staffing data. Work packages for outages can help you get an idea of staffing needs and time elements of a particular job. In conclusion, he called for a cost database from actual decommissioning projects to be developed and made available to the industry.

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40 Months at Chernobyl

A slight change of pace was provided by Jim McIlvaine, from Bechtel SAIC Co., who gave an informal recount of 40 months he spent at Chernobyl, working on the Chernobyl Shelter Implementation Project. Progress at Chernobyl, he said wryly, is moving at about the same breakneck pace as progress at Yucca Mountain.

Oh, To Be Ahead of Schedule and Under Budget

Getting a handle on a large decommissioning project can take a little time, according to Brian Larsen, a planning manager with Kaiser-Hill, the Rocky Flats decommissioning contractor. Right now, work at Rocky Flats is a little ahead of schedule, with costs a bit under budget. But it didn't start out that way, Larsen said. For the first several months, the project was running behind schedule and over budget.

The Millstone-1 BWR, shut down in November 1995, is "cool and dim," on the way to "cold and dark."

In working to improve the situation, the contractor moved to shortened planning cycles, switched from monthly to weekly reports so it could respond more quickly, and identified and deployed more time- and cost-efficient technologies. Among the lessons learned, Larsen said, was that you need a solid project baseline, "so you know when you're in trouble."

As of the time of the presentation, Larsen stated, most of the nuclear materials (uranium, plutonium) onsite should be gone in the next few months, nuclear safety risks are almost gone, and what safety risks remain are industrial, not nuclear. In addition, eight of ten planned soil remediations have been completed, "a lot of waste" has been shipped off, and the company should make the December 2006 cleanup completion deadline.

Because the Rocky Flats site is being returned to greenfield condition, with no onsite waste disposal available, noted Peter Sanford, from SAIC, decommissioning workers at the plant must do a good job of estimating the amount of waste that will be generated during decommissioning and decontamination (D&D) operations. But, he said, decommissioning and environmental restoration waste estimating is notoriously inaccurate due to many project options (for example, whether to decontaminate), characterization uncertainties, and inaccurate assumptions. However, given that the costs of management, transportation, and disposal can range from $15 per cubic foot for LLW up to $500/ft^3 for transuranic waste, reliable waste estimates are essential for budgeting, negotiating, risk estimates, cost/benefit analyses, and many other activities.

Over the years, workers at Rocky Flats have made progress in refining and improving forecasts and estimates, Sanford said. The trick is to continuously revise forecasts as new information is received about decommissioning approaches, disposal methodologies, and other variations from initial assumptions.

News Flash: Plants Can Close Early

Decommissioning "guru" Bill Manion spoke on "Why Operating Reactors Should Plan for Decommissioning Now." He said he has been trying to interest utility executives in this topic for some time but has been "blessed with spectacular failure."

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Utility executives, he said, live with the assumptions that (a) the plant will shut down on schedule, (b) a decommissioning cost estimate will be done two to three years *before* shutdown, and (c) decommissioning operations contractors (DOCs) will be available to bid on the work.

In the real world, he said, this is not happening. Plants can close early, not on schedule. If that happens, he said, "you have to scramble." It can cost an extra $100 million to $150 million to prepare a plan under these circumstances, and these costs are not considered part of the decommissioning costs, but rather part of the operating costs. Some day a regulator may say that these costs could have been avoided. Compare that with the costs to plan *now,* he said. You have utility staff to do the work, and you can take advantage of their expertise. The costs—about 60 000 person-hours of utility staff time, plus about 6000 person-hours of expert guidance, or about $6 million, which can be charged to the decommissioning fund.

As for DOCs, Manion noted that many DOCs were not prepared to develop administrative procedures for the projects they took on. Instead, they often took utility procedures and put their names on them. This led to many problems later on, Manion said.

Utilities today can do a number of activities to prepare themselves for eventual shutdown and decommissioning, including the following:

- Spill research.
- Contaminated soil remediation.
- Fuel performance research.
- Spent fuel pool cleaning ("get rid of some of the junk in the pool").
- Legacy LLW disposal.
- Depleted source disposal.
- ISFSI site selection.

In addition, he said, you must consider the needs of your stakeholders *now*—visit, visit, visit, and keep abreast of what other sites are going through.

In concluding, Manion repeated that even if you think D&D is

decades away, "just maintain the thread," because there will always be unplanned shutdowns.

You Can't Just Send in the Bulldozers

Elias Hanna, from SCE, spoke on the financial aspects of the San Onofre-1 work. Technically, he said, decommissioning is as challenging as construction—you take it out as you put it in; you can't just send in a bulldozer to knock things down.

One very expensive effort at the plant was removal of the large components from the reactor building. A heavy-lift crane was brought in to do the work. It came in 200 shipments and took five weeks just to be set up. Meanwhile, all other work at the plant came to a standstill while the crane was onsite. It was, Hanna concluded, tremendously expensive to use.

The plant is also in the midst of building and loading its ISFSI. Loading fuel was to begin in August 2003, he said. In the meantime, work is ongoing on building the canisters, with one being finished every other month. (The utility is building its own canisters—see "Dry Cask Storage," below.) Under lessons learned, he noted that an ISFSI should be treated just like a plant, not like a stepchild. The ISFSI project should have an independent operations manager.

Switching gears to a more general discussion, Hanna noted that having a decommissioning cost estimate is not the same as having a detailed planning study. Operating plants need to appoint a dedicated decommissioning manager and planning staff, he said. Among the topics the planning staff needs to consider is whether "to DOC or not to DOC." And they need to build relationships with stakeholders while the plant is operating.

Project control tools for operating plants will not work to track decommissioning tasks. For example, he said, the earlier mentioned large component removal operation involved lots of money spent ahead of time, making it hard to track work done with dollars spent. Some projects will be top-heavy with costs.

Also, he said, you need to track LLW packaging efficiency, keeping an eye on the pounds per cubic foot. In addition, you need to track the ratio of LLW to clean waste. Often, he said, the extra costs involved in cleaning up LLW will cut your disposal costs later on.

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Dry Cask Storage

From the NRC Spent Fuel Project

The past year was one in which there was a higher than usual public interest in spent fuel transportation and storage, noted Bill Brach, director of the U.S. Nuclear Regulatory Commission's Spent Fuel Project Office. Also during the past year, six new ISFSIs became operational; the NRC conducted its first inspection of a foreign cask fabricator (Japan); the agency issued two new interim staff guidance documents and revised three others; and they issued new security orders developed in the wake of 9/11.

Challenges ahead include resolutions of high burnup and burnup credit issues, Brach said. Progress has been made on the issue of high-burnup fuel for storage, but there is still a "ways to go" on high burnup for transportation, he concluded.

Do-It-Yourself Canisters

Jorge Morales, from SCE, discussed the progress made in dry fuel storage for the fuel from the decommissioning SONGS-1 reactor. Before they shut down Unit 1, he said, the utility had transferred some Unit 1 fuel to the Units 2 and 3 pools. As Unit 1 fuel is loaded into the ISFSI, the utility will also gather up the Unit 1 fuel from the other pools, which will provide Units 2 and 3 with more pool storage space.

The ISFSI pad is being built on the east side of Unit 1, away from the ocean. The ISFSI will have room for all Unit 1 fuel, plus room for expansion to hold Units 2 and 3 fuel as well. Because the SONGS plants are located in a high-seismic area, the utility is using the horizontal NUHOMS technology.

A few years ago, Morales said, the canister industry was suffering from some severe challenges. Consequently, SCE felt it could not rely on any of the existing canister suppliers, so it made the decision to fabricate its own canisters. The utility turned an unused facility into a canister production shop, hired the workers, defined the procedures, and, using a TN design, began building canisters under license to TN. This may not be the right decision for other utilities, Morales conceded, but it has been the right decision for them. One canister has already been completed, and seven more are in the queue.

The utility purchased a transfer cask from TN (which had been fabricated in Spain) and purchased a transfer cask trailer built in Germany, giving an international flavor to the spent fuel storage project.

Later in the session, Mark Malzahn discussed the ISFSI pad, which is not safety-related. (Vertical casks need a safety-related pad, but San Onofre is using a horizontal system.) The paperwork, however, is in place should it ever need to be safety-related, Malzahn noted. Challenges to the project included finding a supplier of 1400 cubic yards of safety-related concrete (they ended up qualifying a

local commercial batch plant) and then coordinating the delivery of the concrete (143 truckloads) in the wake of enhanced security at the plant (concrete specifications constrain the duration and number of barrel turns after batching). They ended up using a gate that had been closed to plant entry after 9/11; the regulators did not have a problem with that, he said, but it was just another detail to take care of.

A Wealth of Experience from Rancho Seco

Jack Boshoven, from TN, discussed Rancho Seco's loading of fuel to dry casks, which was completed in August 2002. The plant used the NUHOMS MP 187 storage/transportation system and loaded 21 canisters: 2 for fuel alone, 18 for fuel plus control components, and 1 for failed fuel. In addition, one more cask will be used for GTCC waste, so the plant will have a total of 22 horizontal modules in its system. Eight horizontal modules can go into the same space as six vertical casks, he noted.

Joe Wittle, from the Sacramento Municipal Utility District, which owns Rancho Seco, continued the plant's fuel loading story with some lessons learned:

- Always use a single failure-proof crane. They didn't, he said, and so they had to develop cask drop mitigation that ended up costing them more.
- Keep an eye on your vendor. Rancho Seco's vendor went into bankruptcy.
- Underwater video is essential.
- Conduct dry runs before you begin the actual work.
- Start early—the project will take a long time.

At Rancho Seco, fuel was loaded from April to August 2002. As noted previously, they loaded 21 canisters, including one failed fuel can for about 10 failed fuel assemblies.

Commercial Fuel at Hanford?

Rob Rasmussen, from Mid-Columbia Engineering, described a project at the Hanford Site to load a small inventory of commercial spent fuel that was stored in the Hanford 324 Building. The inventory included three pressurized water reactor (PWR) fuel assemblies from Point Beach (Westinghouse fuel), two Calvert Cliffs PWR assemblies (Combustion-Engineering fuel), and two BWR fuel assemblies from Cooper. In addition, there were some loose fuel rods and six quarter-length rods in the inventory. The project involved reconfiguring the assemblies, including removing the top nozzles from the Calvert Cliffs assemblies and removing the upper tie plate from the Cooper fuel. The loose fuel rods were consolidated with full assemblies.

Six old Nuclear Assurance casks were "cleaned up and modified," Rasmussen said, to hold the assemblies. The challenges of the project included degraded fuel conditions (from initial operations); a degraded cask system; multiple fuel designs but only one package design; a remote hot cell environment to work in (much harder to work in than a spent fuel pool, Rasmussen said); seven assemblies but only six casks, forcing BWR fuel consolidation; a limited baseline of information and records on such data as dimensions, burnup, etc.; limited facility clearance and crane capacities; and, finally, what Rasmussen called the "Hanford factor"—any work done there is always "under the gun," he said. The project began in June 2001 and was completed in October 2002.

It can cost an extra $100 million to $150 million to prepare a decommissioning plan if a plant experiences an early shutdown, and these costs are not considered part of the decommissioning costs, but rather part of the operating costs. Some day a regulator may say that these costs could have been avoided.

Trojan

Trojan's fuel loading story was presented by Steven Nichols, from PGE, the Trojan owner. The ISFSI was designed to hold 36 casks—34 for spent fuel and 2 for GTCC waste. However, because Trojan shipped its reactor pressure vessel with the GTCC internals intact, it will not need those last two casks.

Fuel loading began in late December 2002. At the time of the meeting presentation in June, 22 casks had been loaded with fuel and were on the pad. By June, it was taking "just shy of five days" to load a cask, Nichols reported.

The spent fuel racks were to be removed between the loading of cask 33 (scheduled for the end of July 2003) and cask 34 (scheduled for the end of August 2003). After that, workers will drain and decontaminate the spent fuel pool, complete decommissioning, and complete the final survey activities. The plant expects to terminate the Part 50 license in mid-2005, Nichols said.

DOE Projects

Hot Cell Cleanup

Pat Weaver, from Battelle Columbus Laboratories, reported on the decommissioning of several hot cell facilities at the lab. The project involved decommissioning 14 hot cells (from small metallurgy cells to large fuel examination cells), two fuel storage pools, high bay areas, and a machine shop. The hot cells themselves were full of discarded materials and other waste items that had accumulated over the past 30–40 years.

Workers first set up a working space by cleaning out the largest hot cell, loading the trash and waste into casks, and refurbishing lights, infrastructure, and so on. They then set up a sorting/package area.

During characterization of the materials involved, seven staffers were trained as "waste specialists," and they were given "ownership" of the waste. As a result, there have been no verification failures in almost four years, and 90 percent of decisions can be made in the field, saving time and money.

Their goals were as follows:

- Minimizing the generation of mixed waste, which involved strict control of what one could take into the cells and strict efforts to avoid cross-contamination.
- Separating LLW from transuranic (TRU) waste. The initial estimate of 300–400 cubic meters of TRU waste was a "killer." Through effective sorting, the amount of TRU waste has been reduced to about 25 m^3—much more "manageable."

Some mixed waste was found, and Battelle still has no disposal options for the material, especially the mixed TRU waste. "WIPP won't take it, and Hanford has stopped receiving," Weaver explained.

The biggest question on the hot cell cleanup itself is "when do you stop?" After the junk removal, which contained about 75 percent of the source term, Weaver said, they did some remote decontaminations, removed the utilities (cranes, manipulators, windows, lights, wall penetrations, etc.), and are ready for a final decontamination. But there are concerns about hot spots, which could affect demolition activities, and concerns about shipping as well.

As for lessons learned, Weaver said the biggest lesson was to spend the money upfront on upgrading the system—replacing old manipulators, for example—before you begin work. It will save staff time later on.

Having a decommissioning cost estimate is not the same as having a detailed planning study. Operating plants need to appoint a dedicated decommissioning manager and planning staff.

Up and Running . . . and D&D

Patrick Gibson, from the Idaho National Engineering and Environmental Laboratory, reported on a challenging project of decontaminating and decommissioning the Waste Experimental Reduction Facility while it was still occupied and operational. The project involved removing and disposing of a mixed LLW incinerator and related equipment and performing the legal closure. It meant cleanup workers had to remove some building services while keeping others in service and working around building occupants.

The first step was utility dismantlement. The key to success in this project was that facility drawings had been saved and kept up to date. "This saved the day," Gibson said.

Incinerator removal was more problematic. The incinerator itself provided maximum floor loading, so no forklifts could be brought in to help with the work. Instead, workers had to brace the floor from below, build a superstructure over the two incinerator chambers, and use air pallets to move the chambers out. Using the air pallets, the job was completed in two days (one for each chamber), with no building deconstruction necessary. Air pallets were also used to bring out the baghouse, and a BROKK was used to demolish the room. The project was completed ahead of schedule, and under budget.

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A Complex Mission Nearly Complete

Plutonium facility D&D at Rocky Flats was the subject of a presentation by Mark Ferri, from Kaiser-Hill Co. The project involves more than 1 million ft^2 of highly contaminated facilities, approximately 100 miles of process piping, 106 metric tons of plutonium residues (representing 85 percent of the country's inventory), approximately 600 tanks, about 60 plenums, 1325 gloveboxes, buried equipment, and extensive contamination from past fires. "We go through thousands of respirators a day," Ferri noted.

But the nuclear mission at the site is almost over, Ferri said. Work still to be done includes completing packaging of material for the Waste Isolation Pilot Plant, completing placing plutonium metals and oxides into 1850 containers for long-term storage, finishing the shipments of special nuclear material to the Savannah River Site, and closing the remaining protected area. This is all scheduled to be completed by this fall.—*Nancy J. Zacha, Editor*