A report from the American Nuclear Society's Decommissioning, Decontamination, and Reutilization Topical Meeting, held September 16–19, 2007, in Chattanooga, Tennessee.

The Last 5 Percent Seems to Take Forever . . . And Other DD&R Lessons Learned

The American Nuclear Society's Decommissioning, Decontamination, and Reutilization (DD&R) Division Topical Meeting, held September 16–19, 2007, in Chattanooga, drew more than 200 attendees from 12 countries to the Tennessee city. The subject of the conference was "capturing decommissioning lessons learned."

Opening Plenary

Wayne Norton, president and chief executive officer of Connecticut Yankee, noted that while only three nuclear power plants are still in active decommissioning in the United States (Rancho Seco, San Onofre-1, and La Crosse), there are 10 more currently in SAFSTOR. These will eventually need to be decommissioned, he said. As for Connecticut Yankee, Norton said he was expecting the license termination from the U.S. Nuclear Regulatory Commission "this month"—that is, in September.

Norton listed what to him are the key lessons learned from his power plant decommissioning experience:

- Field a strong project team.
- Maintain a credible safety-first culture.
- Manage to aggressive cost, schedule, and dose goals.
- Develop a clear project plan and focus.
- Maintain a strong focus on risk management.
- Have strong regulatory compliance and interface, which is critical.
- Involve stakeholders at all levels.
- Embrace oversight (internal and external).
- Remember that the last 5 percent seems to take forever.

Completing state requirements can take years after the NRC issues the license termination. After the NRC and the EPA are satisfied, the states still get to cast the final vote on cleanup completion.

Speaking more generally, Norton said that "time is your biggest enemy when it comes to cost control." In addition, he noted that waste volumes inevitably grow: "No dig gets smaller."

The biggest concern for him, he stated, was that completing state requirements can take years after the NRC issues the license termination. After the NRC and the U.S. Environmental Protection Agency (EPA) are satisfied, the states still get to cast the final vote on cleanup completion, he said. In addition, he noted, staff retention gets difficult once you have reached the 95 percent complete stage, so his final piece of advice was, "Don't claim victory at 95 percent!"

Sandra Waisley, director of Decontamination and Decommissioning (D&D) and Facility Engineering in the U.S. Department of Energy's Environmental Management (EM) Office of Engineering and Technology, noted that EM is in charge of cleaning up 114 sites in 31 states, comprising 2 million acres (twice the size of the state of Rhode Island), with a budget of $5.7 billion and a workforce of 34 000. The priorities for the years 2008–2012, she said, are to stabilize tank waste; store, stabilize, and safeguard spent fuel and nuclear materials; dispose of transuranic, low-level, and solid waste; remediate major areas of EM's large sites; and perform D&D of excess facilities.

The DOE-EM has also been identified to take on additional scope, she said, mostly on D&D work. This work, which will cost some $10 billion, is currently unfunded.

Waisley continued: EM is currently looking at "smarter" approaches to D&D work, with "smarter" defined as "safer, faster, cheaper." Every month, she said, we identify increased work scopes; we need to get smarter in technology approaches.

In January 2008, she continued, the

Office of Engineering and Technology will unveil a D&D hotline, or, help desk, plus a Web-based system, to enhance the existing hotline and provide help to the various cleanup sites.

Tom LaGuardia, retired from TLG Services and now working as an independent consultant, discussed the early experience in decommissioning in the 1960s and 1970s. These early experiences, he said, raised awareness of the back end of the fuel cycle, including the ultimate disposition of retired facilities, environmental impacts, and D&D costs (including decommissioning funding). These experiences also prompted the regulatory agencies to get involved and drove the development of new industry contractors.

Under recent successes, LaGuardia pointed to underwater cutting of reactor vessel internals (at Maine Yankee, Rancho Seco, Gundremmingen, and the BR3 reactor in Belgium), intact removal of large components (at Shippingport, Trojan, Yankee Rowe, Connecticut Yankee, Big Rock Point, Maine Yankee, and Gundremmingen), and interior/exterior concrete removal (at Trojan, Maine Yankee, and Saxton).

Current challenges, LaGuardia continued, include the following:

- Developing a decommissioning strategy for each nation, addressing political and social issues and financial resources. Availability of disposal sites is a key issue (once Barnwell closes, he pointed out, the United States will be in the same position as many other countries), as is community impact and fund availability.
- Developing internationally consistent regulations for safety and the environment. Our ability to measure has become "too good," he noted—implying that just because one can measure a certain radiation level does not mean it is dangerous.
- Developing new disposal facilities for low-, intermediate-, and high-level waste. These facilities should also be designed to accommodate decommissioning wastes.
- Developing ways to deal with and prevent the threat of terrorism, including increasing material control and security.
- Establishing internationally consistent *clearance* levels for materials.
- Estimating costs accurately and assuring adequate funds for decommissioning.
- Capturing and retaining expertise learned at current projects for future applications. Lessons learned are a valuable tool, but sometimes these involve proprietary information that companies are reluctant to share.
- Obtaining stakeholder confidence in decommissioning feasibility.
- Managing transitions issues and change of culture from operations to decommissioning. This transition will involve planning, informing employees "early in the game" on employment and termination, and taking pride in successful performance (he pointed to the parties thrown at Big Rock Point whenever a major decommissioning milestone was met).

Future challenges, LaGuardia concluded, include providing developing nations with the benefit of early experience, developing improved technologies for dismantling and demolition, and addressing social impacts of decommissioning on local communities. He added that formerly abandoned techniques should be reevaluated for applicability in a changing technological and economic environment; for example, now that disposal is more expensive, cleanup and release makes more sense than it used to.

Hans Riotte, from the Organization for Economic Cooperation and Development's Nuclear Energy Agency (OECD/NEA), noted that everyone wants to talk about decommissioning successes, but sometimes you can learn even more from your failures.

The OECD/NEA's Cooperative Program on Decommissioning (CPD), Riotte said, covers 42 projects, 23 organizations, and 12 countries, with 26 reactors and 16 fuel cycle facilities in all stages of decommissioning. The program provides information exchange. The agency's Working Party on Decommissioning and Dismantling "builds on the technical information developed by the CPD," Riotte said.

As for lessons learned, Riotte noted that key issues include increased attention to *industrial* safety, approvals for modifications of plant and equipment, contamination control, and establishment of a safety culture.

Formerly abandoned techniques should be reevaluated for applicability in a changing technological and economic environment; for example, now that disposal is more expensive, cleanup and release makes more sense than it used to.

On the issue of materials release, Riotte noted that D&D wastes are very similar to operations wastes and that the availability of a disposal pathway influences national policies on clearance. For example, he said, Germany, with no LLW disposal facility, does a lot of cleanup for release.

Commercial Projects

At a session on status of commercial cleanup projects, Bill Trubilowicz, with Operating Solutions of Michigan, discussed the spent fuel cask loading campaign at the Big Rock Point plant. This was the first and only cask loading campaign at the plant, he noted.

The project involved 441 fuel bundles, several of them mixed-oxide (uranium and plutonium) bundles. About 50 of these were classified as "damaged," he said, but there were no "fragments." The Big Rock fuel bundles were 2 meters long (half the size of most commercial fuel), so the bundles were loaded on top of each other in the casks. The project resulted in seven fuel casks and one cask for greater-than-Class-C waste.

Among the lessons learned, Trubilowicz noted, is the importance of contingency planning ("I can't stress enough how important it is," he said). He also described the Big Rock Readiness Review Team, made up of industry experts. We had to get their

permission to run the NRC dry run, as well as the actual loading, he said.

Nothing in the project had to be done fast, Trubilowicz said. Therefore, they took the "calm and methodical" approach, with plenty of practice. As for loading the casks themselves, Trubilowicz stated, "you need an operations mentality not a decommissioning mentality" to do the job right. Finally, he noted that the last canister sat unwelded for 10 days while the spent fuel pool was being cleaned.

Bonnie Spencer, with LATA/Parallax Portsmouth LLC, discussed the Gaseous Centrifuge Enrichment Plant (GCEP) cleanout at Portsmouth, Ohio. The Portsmouth Enrichment Plant began operations in 1956 and closed down in 2001. GCEP was built on the site in the 1980s but never operated. A project to remove the old centrifuge machines and equipment was completed in August 2006, she said. Because the materials were classified, the only disposal solution was to send them to the Nevada Test Site (NTS).

The centrifuges were shipped whole, four to a bundle. This shipment method provided cost savings over cutting them up, Spencer said. In all, 682 000 cubic feet of GCEP wastes were shipped to the NTS, including 1383 machines and 711 containers of centrifuge equipment.

Lynne Goodman, with DTE Energy, discussed the "slow, controlled decommissioning" taking place at the Fermi-1 plant, with a budget that has typically run about $4 million per year. A decision was recently made, she said, to continue this decommissioning project, and an additional $30 million was approved so that the plant could take advantage of the Barnwell LLW disposal facility before it closes. License termination is scheduled for 2012, and the critical path is sodium residuals cleanup and reactor vessel removal, Goodman said.

Michael Anderson, with MOTA Corp., discussed the D&D of CVTR, a research reactor located just north of Columbia, South Carolina. The facility first went critical in 1963 and shut down in 1967. The decommissioning plan was approved in 2000. The cost estimate for the project is around $4 million.

The final waste shipment was made in April 2007, Anderson said. The Moderator Tank Removal Project, which utilized mechanical cutting techniques, took 15 months, with a cumulative dose of 17 person-rem. The site has now begun the demolition phase, Anderson concluded.

Rick Ranellone, from Mega-Tech, and John Wiegand, from the U.S. Department of Transportation's Maritime Administration, discussed the project to determine if the *N.S.S. Savannah's* reactor vessel and internals could be disposed of as Class A waste. Plugs were bored from the reactor vessel of the long-retired nuclear merchant ship and analyzed ("It's not often that a vessel is drilled into," Ranellone said dryly), and the results indicated that the vessel could, indeed, be disposed of as Class A waste. Ranellone attributed this to the excellent performance of the reactor, with no fuel failures. There were trace quantities of cesium-137 in the primary loop, he continued, but no detectable quantities of other fission products.

The availability of a disposal pathway influences national policies on clearance. For example, Germany, with no LLW disposal facility, does a lot of cleanup for release.

Lynne Goodman indicated that they are taking the same approach at Fermi-1. It took about a month to get the results back from the analysis, she continued, and they saved about $2 million in curie burial surcharges.

Jim Miller, from EnergySolutions, described the waste removal and disposition project at the Honeywell Metropolis Works, which operates a uranium conversion facility in Metropolis, Illinois, just north of Paducah, Kentucky. The plant had accumulated quite a backlog of LLW, Miller said—some 4700 tons of it. The waste streams included soil, concrete, dry active waste, uncrushed drums (about 90 000 of them, accounting for about 50 percent of the waste), wood, and asbestos.

The waste removal and disposition contract was awarded in August 2006, and the project was completed in December 2006. In all, 90 railcars of material were shipped, mostly Super Gondolas. Problems for the project included that the work took place on an active site conducting operations 24 hours a day, 7 days a week, Miller said. Another difficulty involved using an inexperienced, nonunion workforce at a unionized site.

A nontraditional technique (using large excavators) was used to crush the empty drums. Several pieces of heavy equipment were also used to transport the waste from the volume reduction and waste storage areas to the gondola loading area, Miller said.

International Projects

At a session on international projects, Stephen Kenney, acting director of Waste Management and Decommissioning Operations with Atomic Energy of Canada Limited at Chalk River, described the D&D of Building 107, the CRL Radioisotope Laboratory, at the Chalk River site. The lab, a wood-framed building situated close to other buildings on the site, was built in 1945, at a time when most buildings were constructed of wood because all metal was going toward the war effort. It was added onto several times in succeeding years.

The project began in December 2005, with the expectation that it would be completed by December 2006, Kenney said. However, while Phase I (primarily the south end of the building) was completed by April 2006, Phase II (the north end) was still "not quite done" at meeting time. All rooms had to be treated the same during the project, Kenney said, whether they were offices, labs, or workshops, because rooms had been renumbered at some point, and there was no way of knowing which rooms corresponded to original plans and therefore no way of knowing what the rooms may have been used for in the past.

One project limitation on the decommissioning was that the amount of contaminated waste had to be kept to less than 500 m^3, and thus workers had to minimize the amount of waste that cannot be free released. Kenney said they have been able to release 2000 m^3 of waste that otherwise would have been sent to active disposal, at a savings of $8 million (the extra labor costs to clean the material for release totaled $250 000).

Total estimated cost of the project was $7 million (Canadian). To date, some $5 million has been spent, and it appears that it will cost about $750 000 to complete the work, Kenney said.

Eric Gouhier, with France's Cadarache Nuclear Research Center, described the decommissioning of the Harmonie low-power reactor. France, he noted, does not allow free release of materials. The Harmonie decommissioning work was divided into three phases: Phase 1, between 2002 and 2004, dealt with conventional waste; Phase II, done between 2004 and 2006, covered zones with nuclear waste, including the removal of the reactor block; Phase III, building dismantlement, began on July 2, 2007. By meeting time, Gouhier said, they were almost down to greenfield. "Delicensing" is expected in 2008. The total cost of the project should come in at between 4 million and 6 million euros ($5.76 million to $8.64 million), he concluded.

Decommissioning the Phenix sodium-cooled breeder reactor was discussed by Michel Soldaini, with the Commissariat à l'Énergie Atomique. The reactor is not due to shut down until early 2009, he said, but a feasibility study on the decommissioning was conducted in 2003. The project is expected to be completed by 2025, and the buildings will be cleaned but not demolished, Soldaini said. Fuel removal is scheduled for 2009–2013. After 2013, the facility will need a new license before they can go ahead with decommissioning, and that may take about three years.

All of the sodium will be treated onsite, Soldaini continued, and much of it will be reused in a new Generation IV reactor to be built on the site.

Corazon Bernido, deputy director of the Philippine Nuclear Research Institute, noted that there are some 200 research reactors worldwide that are currently shut down and in need of decommissioning. The International Atomic Energy Agency has selected the Philippine Research Reactor (PRR-1) for its International Research Reactor Decommissioning Demonstration Project, called R2D2, to provide a model for future decommissioning projects. The project started in 2006 and is expected to extend to 2012.

In a project to determine if the N.S.S. Savannah's reactor vessel and internals could be disposed of as Class A waste, plugs were bored from the reactor vessel of the long-retired nuclear merchant ship and analyzed. The results indicated that the vessel could, indeed, be disposed of as Class A waste.

The PRR-1 was obtained under the Atoms for Peace program, Bernido said, and began operations in 1963. It was converted to a TRIGA reactor in 1984 and restarted in 1988. However, a serious leak developed almost immediately in the pool liner, and because of limited funds, the liner was not repaired until 1997. Other problems prevented the resumption of operations, and a formal decision to decommission the unit was made in 2005. The TRIGA fuel elements, used for only about 18 hours, are still in the building.

Radiological characterization started in 2007, and the decommissioning plan is expected to be completed in 2008, Bernido said. They are hoping to obtain unrestricted release for the reactor building, because "the Big Egg," as it is called, is a landmark in Manila. They are hoping to convert it to a museum or something similar. They plan to ask for DOE funding to build a storage site for the spent fuel.

DOE Projects

At one of several sessions on DOE projects, Greg Boris and Frank Cater, both with Bechtel Jacobs, described some of the problems with the upcoming D&D of the K-25/-27 buildings on the Oak Ridge, Tennessee, site. The buildings made up the Gaseous Diffusion Plant, which operated between the 1940s and the 1980s. After shutdown in the 1980s, no repairs have been made to the roof, and things "have degraded since the shutdown," Boris said. In fact, Boris stated later, a brood of turkey vultures is living in K-27.

Cater noted that the K-25 building, consisting of 44 acres under one roof, was built under wartime directives to conserve steel and was never reinforced later. Two-thirds of the top floor, made of precast concrete panels, is condemned, he said, and one person has already fallen through. The lack of proper reinforcing "increases the likelihood of failure during demolition," Cater said. So the challenge will be "to keep it together long enough to take it down."

The basic demolition process will be to remove the steel structure, then remove equipment, and finally remove the concrete. The north end of the building ("the end of the U in the U-shaped building") will be saved as a museum, Cater said.

Boris addressed the efforts to reduce technetium-99 contamination in the buildings. The isotope, a low-energy beta emitter, is present because, Boris said, in the early days, operators recycled fuel and reintroduced it through the centrifuge. The fission product migrated to some areas of the process and caused some operational problems in the cascade. Today, 14 units are believed to have some Tc-99 contamination, with 32 kilograms expected to be present in K-25 and 30 kg in K-27. Because of this, contamination control efforts will include the use of fixatives over 10 percent of the K-25 floor space and 100 percent

of the K-27 floor space, water misting, and the use of personal protective equipment for workers. The plan is to do the K-25 area that has the Tc-99 contamination last and then to move to the K-27 building. All the Tc-99–contaminated material will have to be shipped to an offsite facility, Boris said. Right now, the contamination exceeds NTS limits, but he expects that they will receive a variance.

All of the sodium from the Phenix reactor will be treated onsite, and much of it will be reused in a new Generation IV reactor to be built on the site.

Surajit Amrit, with Bechtel Jacobs, described some of the difficulties with the explosive demolition of a 60-year-old firewater tower at the Oak Ridge site. In fact, he said, two previous attempts to bring down the 100 000-gallon tank, 175-ft-high tower had failed.

The first problem was that several occupied facilities are located within a 500-ft radius of the tower. There was a risk that the tank could be decapitated and roll downhill. This risk was mitigated by establishing a blast exclusion zone and by doing the work over a weekend.

The second problem was caused by a standpipe in the center of the tower, which stood in the way of the clean felling of the facility. The solution was to remove a 20-ft section of the pipe at the bottom of the tower immediately before demolition.

The third problem was that overnight onsite storage of explosives was not permitted. Consequently, the project had to carefully plan the transport, delivery, and receipt of the explosives.

Other challenges centered on what to do if the explosives did not go off as planned and if the tower did not fall as planned. Careful research and information from lessons learned from similar projects helped project managers convince authorities that the project would work as planned.

During the event, the demolition went pretty much as planned, Amrit said. On the plus side, he continued, the noise level was as predicted, there was a negligible dust plume, there was no collateral damage to roads or utilities, the tank did not come loose, and the weather cooperated. On the minus side, he conceded, a small brush fire resulted (misting of area vegetation would be a good idea in any future similar projects, he advised), and the explosives took more time than planned to arrive onsite. The demolition resulted in 1800 ft^3 of debris.

The Wrapup

Unlike most topical meetings this reporter has attended, this conference featured a *closing* plenary session to provide a meeting wrapup. Leading off in the session was Bill Manion, often called "the father of nuclear decommissioning." Manion discussed the need for operating nuclear power plants to plan *now* for decommissioning. Even in these times of license renewals, there are no guarantees of how long a plant will operate, he cautioned, and an unplanned early shutdown is very expensive.

Two-thirds of the top floor of the K-25 building at Oak Ridge, made of precast concrete panels, is condemned, and one person has already fallen through. The lack of proper reinforcing "increases the likelihood of failure during demolition," so the challenge will be "to keep it together long enough to take it down."

Preplanning for decommissioning will cost about $6 million, Manion figured, and it can come out of the decommissioning fund. For a utility to benefit from the planning, they have to do it themselves, Manion continued; a cadre of six people who will do double duty for a time (their own work and the decommissioning planning) should suffice. Think of it as insurance, he added.

Manion urged utilities to consider several issues in the decommissioning planning:

- Which systems can be abandoned immediately after shutdown? If you can identify those early on, it gives you jobs to be done with things are slow.
- What will be the approach for spent fuel storage—wet, dry, some of both? Identify where you are going to put your independent spent fuel storage installation, and do what needs to be done to prequalify it.
- Do you want to do a chemical decontamination? If so, include it in the plan, keeping in mind, he said, that the best decontamination factor he had seen from chemical decons was around 10.
- Write a generic procedure on cutting equipment apart and generic procedures for radiation control, and then let the guys in the field make the fine tunes.
- Develop plans for the utility to be the project manager. That's the approach that works, Manion said. He added that the ideal decommissioning operations contractor, who knows what to do and is ready to go and who has the infrastructure to do it, doesn't exist—"but you can't tell utility managers that."
- Prepare applications for state and local permits, and draft all the documents that will be needed for licensing and permitting.
- Have the contracts people put together contract bid documents for

those tasks that you will have to contract out.

- Research the site spill history and prepare the site/water contamination profile. Remediate contaminated soil *now* not later. Dispose of legacy LLW if possible.

Sandra Waisley noted that $153.2 billion worth of work still needs to be done in the DOE-EM program, so the DOE is very interested in tracking lessons learned. In 1991 the 33 000 DOE contractors across the United States formed the Energy Facility Contractors Group, and that organization formed a working group in October 2006 called the Deactivation and Decommissioning and Facility Engineering Working Group, which plans to publish best practices and lessons learned from recent experiences. They also plan to initiate a D&D hotline and help desk, an extension of the successful Hanford ALARA Center, Waisley said.

Rex Norton, director of Contracts and Requisitions for Fluor Fernald, listed some lessons learned from his experiences:

- Restore groundwater to drinking water standards (as opposed to background levels).
- Perform offsite cleanup to achieve risk-based criteria (versus background).
- Dismantle *all* facilities.
- View onsite disposal as necessary and acceptable. Under a "balanced" approach to cleanup, he continued, you leave the low-level, high-volume stuff onsite. There is a 10-fold difference in price between on- and offsite disposal.
- Plan more work than you have the money for (up to 10 percent more); then look for ways to pinch pennies, knowing there is more work to be done.

Gerry van Noordennen, from Connecticut Yankee, stressed that operating plants must pay attention to the NRC directive issued on September 12, 2007, to include groundwater monitoring as part of reactor oversight. The NRC will now be looking for leaks and contamination, he said, and underwater piping is the best source for contamination and leakages. Operating plants should establish a groundwater monitoring program early in life and enclose underground piping in duct banks or concrete trenches or encase pipe with leak-detecting capability. They should also repair leaking tanks or underground piping at the first opportunity and, importantly, keep the local community informed.

Connecticut Yankee had some groundwater issues, he continued, and spent $75 million for soil and bedrock remediation and another $10 million on groundwater monitoring and model development. He noted that operating plants remediate to millirem-per-hour levels, while D&D has to remediate to *millirem-per-year* levels.

As part of the final wrapup, Jim Byrne, the meeting's technical program chair, reminded the attendees that the next DD&R conference will be held in 2010.—*Nancy J. Zacha, Editor* ■

DD&R Awards

DD&R Division Chairman John Parkyn (left) presents the 2007 DD&R Project Excellence Award to Gerry van Noordennen, from Connecticut Yankee. Van Noordennen accepted the award on behalf of Wayne Norton, who was unavailable during the awards luncheon.

DD&R Division Chairman John Parkyn presents the 2007 DD&R Lifetime Achievement Award to Tom LaGuardia for his contributions and leadership in the decommissioning area.