D&RS 2016

Applying lessons learned and remote-operated systems to D&D

The potential and limitations of advanced technologies for the decommissioning and decontamination of nuclear facilities were discussed during a joint topical meeting of ANS's Decommissioning and Environmental Sciences and Robotics and Remote Systems Divisions.

The American Nuclear Society's Decommissioning and Environmental Sciences Division and Robotics and Remote Systems Division hosted a joint topical meeting, Decommissioning and Remote Systems (D&RS 2016), held July 31–August 4 in Pittsburgh, Pa. The conference, according to organizers, provided an excellent update on the technology of nuclear installation decommissioning, as well as the state of the art for remote operations and robotics technology.

As the home of Westinghouse Electric Company, the city of Pittsburgh was a fitting setting for the conference, according to Yves Brachet, the general chair of the meeting and Westinghouse's vice president of decontamination, decommissioning, remediation, and waste management. In his comments at the opening plenary session, Brachet noted that Pittsburgh is a great example of a city that has successfully remediated its industrial legacy, transforming itself from a city plagued by pollution to a clean, economically vibrant center. This was done rather quickly over the course of a few decades, Brachet said, due to the willingness of the community to make the right combination of political and economic decisions. Brachet stressed the importance of public perception and acceptance, saying that the lack of public acceptance can kill an industry.

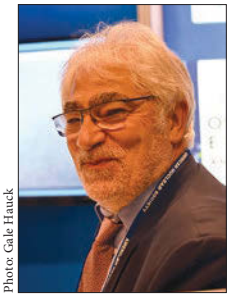

Photo: Gale Hauck

Brachet

In pointing out the success in recent decades of cleaning up brownfield sites in the United States, Europe, and elsewhere, Brachet used the automotive industry as an example of how public acceptance can influence industry practices. Having lived in Europe 40 years ago, he said that it was not uncommon there, nor was it in the United States, to see large lots of junked cars along the highways. Again, based on economic and political factors, the auto industry changed its image, and now almost 80 percent of a scrapped car is either reused or recycled. The reuse and recycling of old cars is now touted as a selling point, Brachet said, adding that it is used as proof that the auto industry is taking care of its legacy waste.

Brachet said that the nuclear industry needs to apply the lessons of automotive manufacturing and other industries, and he reiterated the position that the general public will be more favorable to new-build projects if the industry can show that it is effective in decommissioning and removing its closed power plants and managing its waste. He added that he is aware of the economic challenges to completing decontamination and decommissioning projects, noting that some reactor owners will opt for safe storage (SAFSTOR) in order to allow their decommissioning funds to grow enough to cover the cost of D&D. He advised against waiting too long, however, arguing that there is no certainty that in 20 years' time, the costs associated with regulations, D&D work, and waste storage will not increase faster than a plant's decommissioning funds. "We will be running after something that is very difficult to reach," he said.

Delaying the decommissioning of shutdown reactors also gives the public the impression that there is a lack of commitment on the part of the nuclear industry to

take care of its legacy, Brachet said, adding that an ideal timeline for remediating a closed reactor is about 30 years. "It is long, but at least it is acceptable," he said.

While Brachet focused on timelines and public perception, the plenary session's keynote speaker, William Magwood, discussed the challenges posed by changing regulations and the difficulty of calculating reliable cost estimates for D&D projects. A native of Pittsburgh, Magwood is a former commissioner of the Nuclear Regulatory Commission and the current director-general of the OECD Nuclear Energy Agency (NEA). Magwood said that much of his talk was based on work done by the NEA's standing committees, including the Radioactive Waste Management Committee, which supports international cooperation in nuclear decommissioning and long-term radioactive waste management.

Magwood also drew on his experience at the NRC, noting that during his tenure, there was a lot of discussion within the agency on the "rules of the road" for nuclear decommissioning. The changing regulatory environment, both in the United States and abroad, is going to have a big impact on how D&D gets done, Magwood said. "Probably the most important message I will have for you today is that the ground is shifting under your feet," he said.

Photo: Gale Hauck

Magwood

As an example, Magwood used the Lubmin (also known as Greifswald) and Rheinsberg nuclear power plants in Germany, whose six reactors have been shut down since 1990. In 1994, he said, the cost estimate for decommissioning the reactors, with the goal of returning the sites to greenfield status by 2015, was about €3.2 billion (about $3.6 billion). That estimate went up to €4 billion (about $4.5 billion) in 2012, and to about €6.5 billion (about $7.3 billion) in 2016, with a completion date of 2028. "It would not surprise me at all if, in three years from now, there was a different estimate," Magwood said, adding that while the situation in Germany is unique, he is seeing similar conversations in other countries.

Magwood pointed out that of the nearly 160 reactors around the world that have been shut down, only 15 have been fully decommissioned and taken back to greenfield status. This presents a challenge, he said, in that our experience and knowledge base on returning a nuclear site to a greenfield state is limited. The problem is not in our understanding of the technologies and methodologies for doing nuclear D&D; those are well understood, Magwood said. The problem is that the limited experience in completing projects makes it difficult to produce reliable cost and schedule estimates.

According to Magwood, this inability to make reliable estimates creates an "atmosphere of uncertainty." As Brachet previously pointed out, uncertainty can produce a barrier to new nuclear development, as it can result in a push by the public, regulators, and governments to call for the industry to set aside even more resources for decommissioning than is already required.

There are, however, a number of things that can be done to improve the situation, Magwood said. One is to collect all available data in an attempt to create cost and schedule benchmarks. Magwood pointed to a report that the NEA produced in conjunction with the International Atomic Energy Agency and the European Commission. That report, *2012 International Structure for Decommissioning Costing of Nuclear Installations*, provides a comprehensive way to estimate decommissioning costs on an international basis. While Magwood called the report a good start, he noted that it is only part of the story. Much more data needs to be made available, he said, noting that companies and countries are not always forthcoming in sharing the details of their decommissioning experiences.

To take advantage of advanced technologies, the industry needs to be looking at ways to demonstrate such systems on a cooperative basis.

Technological innovation is another area that Magwood pointed to in which decommissioning can be made more efficient and effective. This includes research and development in advanced technologies, including robotics and remote systems. To take advantage of advanced technologies, Magwood said, the industry needs to be looking at ways to demonstrate such systems on a cooperative basis. "There is a lack of risk-taking, where projects do not want to take risks on new technologies, and therefore it is hard to get new technologies tested," he said.

Magwood also touched on the policy side of nuclear energy, which he said is affecting both closed and operating plants in the form of unstable energy markets. Changing policy, he said, is the biggest challenge and will require a great deal of work to reform.

D&D lessons learned

With five nuclear power reactors having recently been shut down and more at risk of being closed, the United States is facing a new wave of large reactor decommissioning projects. A special session brought together leaders from the country's previous round of reactor decommissioning to discuss issues and lessons learned that are still relevant to today's D&D programs.

Lansing Dusek, director of regulatory affairs for Fluor, provided an overview of the decommissioning of the Trojan nuclear power plant in Oregon, which, after 16 years of operation, closed in 1992 because of leaks in the plant's steam generator. D&D of the pressurized water reactor began in 1993, and its 10 CFR Part 50 license was terminated in 2005.

Dusek

In laying out some of the challenges of the Trojan decommissioning, Dusek noted that much about the project was unique, requiring original thinking to solve problems. In 1999, Trojan encountered what Dusek described as the first "hiccup" of the D&D project during the first attempt to transfer the reactor's spent nuclear fuel to dry storage. The steel fuel canisters, which had not been fully coated, had begun rusting in the spent fuel pool. The issues with the canisters were resolved, and the fuel transfer to the site's independent spent fuel storage installation (ISFSI) was completed in 2003.

Highlighting one of the successes of the Trojan decommissioning, Dusek noted the removal and disposal of the reactor vessel and internals. Portland General Electric opted to cement the reactor internals and dispose of the reactor vessel at US Ecology's facility at the Hanford Site in Washington. This helped the project come in under budget, Dusek said, even with the additional costs associated with the spent fuel transfer. In the end, he said, the Trojan project came in more than $30 million under budget.

Some of the keys to successful large reactor decommissioning outlined by Dusek—gathering an experienced leadership team, employing the existing workforce as much as possible, and working with community engagement panels and advisory boards—were reiterated by the next speaker, Russell Mellor, president of Shipsrock Consulting. Mellor discussed some of the lessons learned during the decommissioning of the Yankee Rowe and Connecticut Yankee nuclear power plants.

Continued

In reviewing the cost of decommissioning, Mellor noted that it cost $608 million to decommission Yankee Rowe and $871 million to decommission Connecticut Yankee. "The general takeaway is that it is not cheap," he said.

Mellor

Among what he called the important general lessons of the Yankee experiences, Mellor listed safety first. Poor safety practices, he said, lead to longer periods of stopped work and increased costs. And, he added, the actions taken after a problem emerges are significant. When faced with a setback, a D&D management team must work to understand the problem, gather as much information as possible, and follow a good decision-making matrix, he said.

As for lessons specific to the Yankee reactors, Mellor noted the importance of controlling radioactivity and not letting contaminants migrate off-site, as well as the need to do a complete site characterization. He also stressed that proven techniques should be used as much as possible. When there is no other choice but to use new or novel techniques, he said, crews need to exhaustively mock-up test designs and methods to ensure that they will work as intended.

Given its location, fitted snugly between the Pacific Ocean and Interstate 5, the decommissioning of Unit 1 of the San Onofre Nuclear Generating Station presented an unusual challenge. Richard St.Onge, director of nuclear decommissioning projects for Black & Veatch, discussed some of the challenges of working at San Onofre, where limited site space made special demands on planning and operations.

St.Onge characterized the D&D of San Onofre-1, which closed in 1992, as a project in spent nuclear fuel storage. That is because the decommissioning of the reactor and its buildings was done in large part to make room on the site for the plant's ISFSI. St.Onge said that the deadline to complete the ISFSI was 2006, and the decommissioning of San Onofre-1 began in 1999.

St.Onge

Despite the restrictions imposed by the physical space, St.Onge said, the management of the reactor vessel posed one of the biggest challenges to the project. Southern California Edison was unsuccessful in gaining the necessary permits to ship the reactor vessel to the Barnwell disposal facility in South Carolina. The vessel remains onsite, awaiting the decommissioning of Units 2 and 3.

Much of the Unit 1 decommissioning work, however, was done prior to the September 11, 2001, terrorist attacks, which made operations much simpler than they are today, St.Onge said. Waste haulers, for example, did not have to undergo as extensive a security check when driving in and out of the site.

Bruce Watson, of the NRC, closed out the special session with a discussion of the regulatory experience in the decommissioning of nuclear power plants. Watson, who is chief of the NRC's Reactor Decommissioning Branch, focused his talk on the agency's progress in revising its rules on reactor decommissioning, which Magwood had touched on in his plenary speech.

Watson

The new regulations are intended to improve the efficiency of transitioning from the operations phase of a nuclear power plant to the D&D phase. Currently, plant operators must seek license exemptions from the NRC as systems are shut down and fuel is removed from the reactor core after a plant is officially closed. According to Watson, under the current rulemaking schedule, the NRC will release the regulatory basis for the new rules in November of this year, with a proposed rule issued by 2018, and the new rule issued in 2019.

While facility owners and operators, contractors, and regulators all value the use of mature, proven technologies in conducting nuclear D&D, there are times when new technologies need to come into play.

Robotics and remote operations

While facility owners and operators, contractors, and regulators all value the use of mature, proven technologies in conducting nuclear D&D, there are times when new technologies need to come into play. A prime example of that is in the inspection and maintenance of underground waste tanks at the Department of Energy's Hanford Site near Richland, Wash. The hazardous nature of the waste, along with limited accessibility, makes the tanks an ideal venue for specialty robots.

The technical session "Robotics and Remote Operations in Hazardous Facilities—III" explored some of the robotic systems being developed to inspect Hanford's AY-102 double-shell tank, which in 2012 was found to be leaking waste from its primary shell. Dwayne McDaniel, a senior scientist at Florida International University (FIU), detailed the university's development of a peristaltic robotic crawler to inspect the tank, accessing it through ventilation pipes.

According to McDaniel, the crawler will need to travel about 100 feet, crawling through pipes less than 4 inches in diameter while withstanding temperatures of around 170 °F and radiation of about 80 rad per hour. The crawler will be mounted with a camera and front and back grippers for collecting samples. A modular design is being used to allow the crawler to travel through the pipes and turn through any bends. Pneumatic actuators are used to create the peristaltic movement of the crawler.

McDaniel said that the crawler is currently being tested on a full-scale mock-up of the piping system and that future iterations of the crawler will include additional sensors and nondestructive examination capabilities.

Another remote-controlled inspection tool that FIU is developing for Tank AY-102 was introduced by Michael DiBono, an undergraduate student at FIU. Unlike the peristaltic crawler, the small, four-wheel rover DiBono is working on is designed to travel through the narrow refractory air slots beneath the base of the primary tank shell. The rover will need to access dimensions as small as 1.5 in. × 1.5 in. and will need to be capable of making 90-degree turns. Four motors—one connected to each wheel—allow the wheels to move independently in order to make the tight turns. To avoid traveling over debris, the rover uses magnets that allow it to roll upside down, clinging to the bottom of the carbon steel tank.

DiBono said that one of the challenges his team faced was in designing a cable management system that would both tether and remotely control the rover. The system had to let out cable easily enough to allow the rover to move without resistance, but to also be capable of precisely reeling in the cable to recover the rover. The team settled on a reel and winch system for the cable.

DiBono said that his team will explore an alternative design that will use only two wheels, allowing the design to be made even smaller.—*Tim Gregoire* NN