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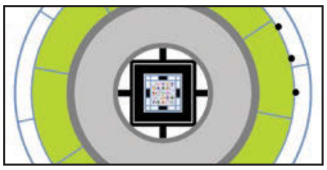
Volume 25, Number 1 Spring 2018

Commentary

Waste Management



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On the Cover:

An SNF overpack is moved onto an ISFSI pad. With a national repository for spent nuclear fuel on hold, the DOE continues to plan for the eventual removal of SNF and GTCC from stranded sites. Turn to page 57 for more.
(Photo: NAC International)

Next Issue:

- *Decontamination and Decommissioning*
- *Environmental Remediation*
- *14th Annual Buyers Guide*

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(Not so) happy anniversary

It would be a mistake to assign too much value to anniversaries. After all, they merely mark arbitrary points in time. Recognizing important past events, however, can be an instructive, if not cathartic, exercise. Anniversaries remind us of what is important, show us how far (or not) we have come, and point us to a (hopefully) better future. Just as a physical landmark will demarcate an important location, the temporal milestone of an anniversary will demarcate an important moment in time.

This year will see a number of notable anniversaries, including the centennial of the armistice to end World War I and the 50th anniversary of the Nuclear Nonproliferation Treaty, which was opened for signing on July 1, 1968. The year 2018 is also the 50th anniversary of the release of Stanley Kubrick's *2001: A Space Odyssey* and the debut of *Mister Rogers' Neighborhood*.

There is, however, another less satisfying anniversary being marked this year, and that is the 20th anniversary of the U.S. government's failure to act on its nuclear waste commitments under the Nuclear Waste Policy Act (NWPA). By January 31, 1998, the Department of Energy was to start accepting the nation's used nuclear fuel and high-level radioactive waste and moving it to a permanent repository. Looking back, 1998 was not a particularly good year. It is also the year of the Clinton-Lewinsky scandal and, at the risk of sounding flippant, the end of TV's *Seinfeld*.

While few in the nuclear industry need reminding of the NWPA's unfortunate anniversary, the National Association of Regulatory Utility Commissioners (NARUC) used it as an opportunity to urge lawmakers to act on nuclear waste and provide funding for the Yucca Mountain license review. In a press release, NARUC noted that the DOE's failure to take possession of used fuel has cost taxpayers more than $5 billion, and damages could reach more than $29 billion by 2022. "Taxpayers and ratepayers have poured literally billions into the federal nuclear waste program, and the liability costs continue to increase every day we delay," NARUC President John Betkoski III said in the release.

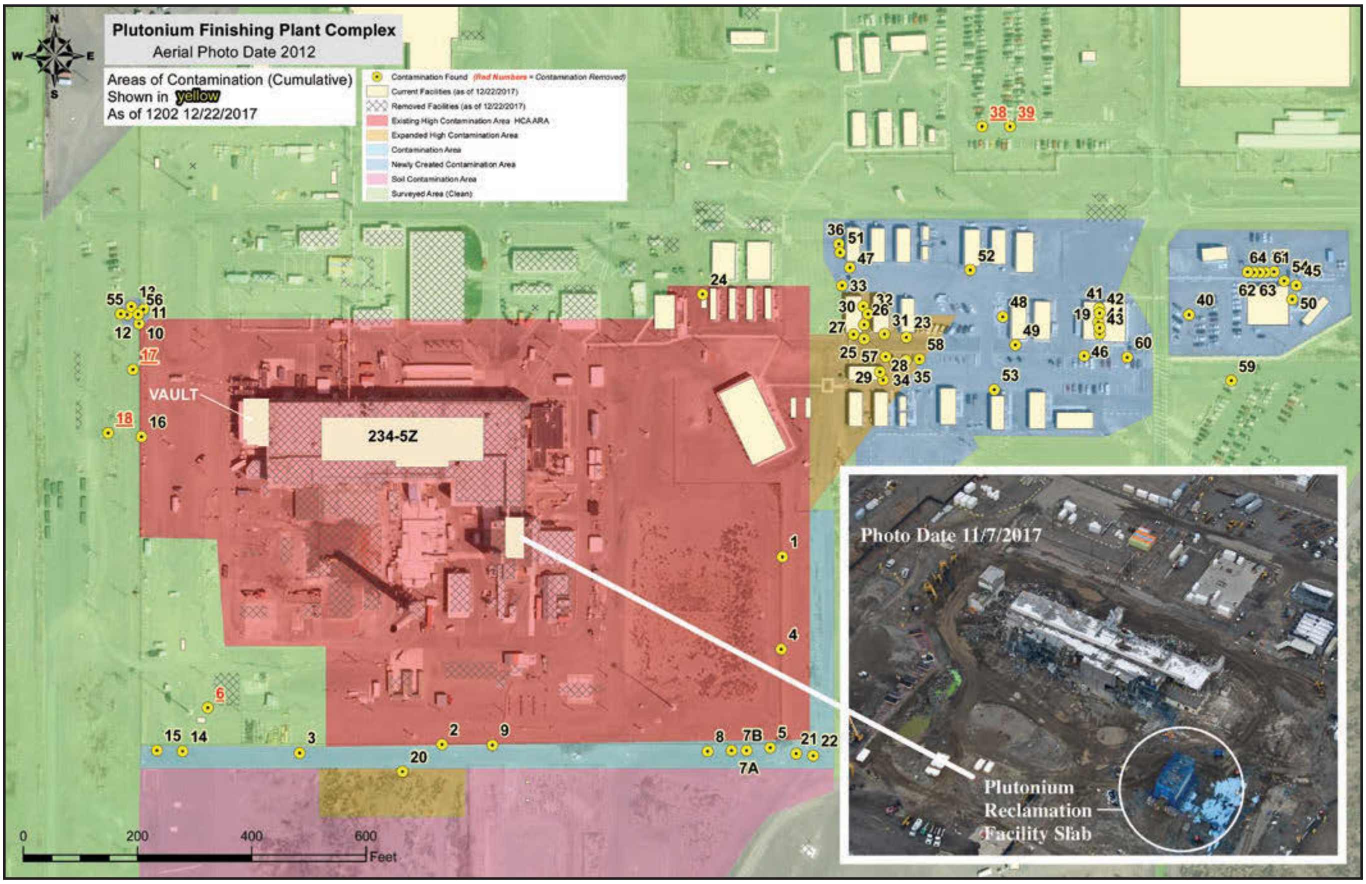
Another year passes, and another missed deadline is remembered.

It is an encouraging sign that President Trump's 2019 fiscal year budget once again includes $120 million for Yucca Mountain, and that the Nuclear Regulatory Commission is asking for nearly $50 million for work related to the Nevada repository. And yet, given the fate of past budgets, it is difficult to see any headway being made anytime soon. The political will, it seems, is still not quite there.

In the absence of any substantial progress being made, however, there are some things being done to help clear the path, so to speak. The DOE, through an integrated waste management system, continues to plan for the eventual large-scale transport of used fuel from reactor sites. As part of this effort, the department has commissioned a number of studies aimed at zeroing in on the best routes for shipping used fuel from power plants to a hypothetical storage/disposal facility (see "Getting Rid of Inventory," starting on page 57).

Likewise, utilities and reactor operators, facing indefinite storage periods, are stepping up their aging management strategies. This includes everything from maintaining safe criticality control in spent fuel pools over longer periods (see page 40) to ensuring the integrity of dry storage systems over multiple decades.

While we wait for political direction, there is some reassurance that we are not sitting idly by. But then again, let's hope that we will not be "celebrating" this anniversary again in another 20 years.—*Tim Gregoire, Editor*



An overlay map shows spots around the Plutonium Finishing Plant demolition site where, as of December 22, contamination was found (yellow dots), along with the existing high-contamination area (red), expanded high-contamination areas (brown), contamination area (light blue), newly created contamination areas (dark blue), soil contamination area (purple), and clean areas (green). (Image: DOE)

Hanford's PFP demo on hold

Demolition of the Plutonium Finishing Plant at the Hanford Site near Richland, Wash., was suspended indefinitely on Dec. 17, 2017, after the Department of Energy's cleanup contractor, CH2M Hill Plateau Remediation Company (CHPRC), found specks of low-level contamination outside the facility's demolition zone. CHPRC workers were focused on the demolition of the PFP's remaining building, the main processing facility, when the stop work order was given. The DOE had hoped to complete demolition work by early 2018.

CHPRC had suspended PFP demolition work on December 13 after elevated readings were found on contamination-monitoring lapels worn by Hanford employees. That stop work order was lifted the following day.

According to a DOE timeline, CHPRC workers discovered particles of contamination outside the PFP's established control areas on Friday, December 15, following the completion of the final demolition of the PFP's Plutonium Reclamation Facility (PRF). Heavy winds in the area on Sunday night and early Monday are thought to have spread the contamination, as follow-up surveys found contamination on several vehicles and outside mobile office trailers at the plant. No contamination was found inside the trailers or on personnel leaving the trailers, according to the DOE. As of January 4, however, 267 Hanford employees had requested bioassays.

Personnel and their vehicles were surveyed for radiological contamination as they left the plant, according to the DOE. About 100 vehicles were surveyed, and low levels of contamination were detected on the exteriors of four government vehicles and four personal vehicles and inside one of the government vehicles. The vehicles were decontaminated and released, the DOE said.

After surveying areas around the plant using vehicle-mounted and handheld radiation detectors, workers covered detected spots of contamination with a product called soil cement to prevent the materials from becoming airborne. CHPRC also stabilized the PRF debris pile to prevent the further spread of contamination.

In response to the contamination, CHPRC expanded its control boundaries around the PFP demolition site. According to the company, the new boundaries go beyond those established as a result of a contamination event on June 8, 2017, and the elevated lapel readings on December 13. The control boundaries were

again expanded on January 7 out of what the DOE called an abundance of caution.

While there appears to be no single event that caused the spread of contamination, the contamination found indicates that it was most likely related to the final demolition of the PRF, according to the DOE. The department said that it will continue to conduct additional radiological surveys and will decide when demolition can resume, and that will be only after it has been assured that CHPRC is fully prepared to resume the work. The DOE is providing updates on PFP activities on its Hanford website, at www.hanford.gov.

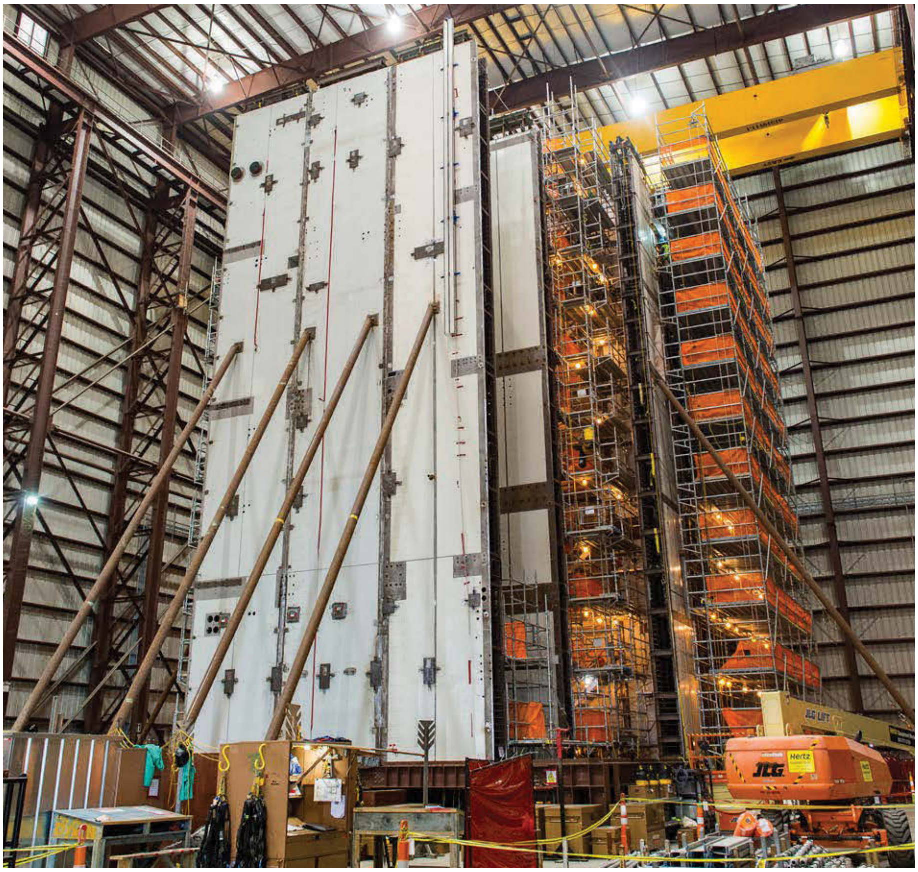
More Hanford news

Technical issues have delayed the completion of Hanford's Waste Treatment and Immobilization Plant, known as the Vit Plant. (Photo: DOE/BNI)

The Department of Energy's strategies for resolving technical issues with the Waste Treatment and Immobilization Plant (WTP) at the Hanford Site near Richland, Wash., are not enough to ensure the safe operation of the plant, according to a report by the Defense Nuclear Facilities Safety Board (DNFSB). The technical report, which has a June 2017 publication date, was delivered to James Owendoff, acting assistant secretary of the DOE's Office of Environmental Management, on Oct. 12, 2017.

The report provides an analysis of control strategies the DOE is proposing to address safety issues associated with flammable gas and criticality hazards at the WTP's Pretreatment Facility. The DOE is designing and building the WTP, also known as the Vit Plant, to treat 56 million gallons of radioactive waste stored in 177 underground tanks at the Hanford Site. The Pretreatment Facility is designed to receive the Hanford tank waste and separate it into low- and high-level waste streams for immobilization through vitrification.

The DNFSB previously identified safety issues related to the challenges associated with Hanford's tank waste and the design of the Pretreatment Facility. In 2009, the DNFSB reported that stagnant waste in piping could lead to the buildup of hydrogen and potentially create an explosion hazard. The board has also raised issues with the performance of the facility's pulse jet mixing systems. Inadequate mixing of the liquid waste could lead to an accumulation of hydrogen in process vessels, a potential



DEMAG

An artist's rendering of the contents of PUREX Tunnel 2 (Graphic: DOE)

explosion hazard, and an accumulation of fissile material at the bottom of the process vessels, a potential criticality hazard.

In 2012, to address the safety issues, the DOE scaled back design and construction work at the Pretreatment Facility and began a phased approach to treating Hanford's tank waste. In a January 24, 2017, letter to the DNFSB, the Office of Environmental Management outlined the progress it has made in addressing the issues and described its strategies for resolving them. The office concluded that the work the DOE and its contractor, Bechtel National Incorporated, had performed was sufficient to resume design work in areas of the Pretreatment Facility affected by the identified safety issues.

In reviewing the DOE's proposed strategies for resolving the issues, the DNFSB said that it has identified several deficiencies that the DOE must resolve to ensure the safe operation of the Pretreatment Facility. The technical report, *Flammable Gas and Criticality Hazards at the Waste Treatment and Immobilization Plant,* can be found on the DNFSB website, at www.dnfsb.gov/documents/reports.

● The Department of Energy announced on Dec. 5, 2017, that a second Hanford Site waste storage tunnel, known as Plutonium Uranium Extraction Plant (PUREX) Tunnel 2, will be stabilized using engineered grout. The announcement follows the completion of the grouting of PUREX Tunnel 1, which on May 9, 2017, was found to have partially collapsed.

The two waste storage tunnels were built adjacent to the PUREX plant to contain railcars holding used plutonium processing equipment and other contaminated materials that could not be readily disposed of by other means. Tunnel 1, constructed in 1956, is about 360 feet long and contains a total of eight railcars. Tunnel 2, which went into operation in 1964, is nearly 1,700 feet long and contains 28 railcars.

Following the collapse of Tunnel 1, DOE contractors backfilled the 20-foot-wide breached area with soil and placed a polyethylene tarp over the length of the tunnel to minimize water intrusion. To prevent further collapse, the DOE decided to fill the tunnel with engineered grout. According to the DOE, the grout will stabilize the tunnel, reduce risk to workers and the environment, and allow for the future disposition of the equipment and materials inside the tunnel. The grouting of Tunnel 1 began on October 3 and was completed on November 11.

Following the collapse of Tunnel 1, a structural analysis of both tunnels was conducted. While the reinforced steel and

concrete Quonset hut–style construction of Tunnel 2 was considered more robust than the shorter tunnel, the analysis concluded that Tunnel 2 was at a "high risk" of collapse and that efforts to stabilize it were warranted. After considering a number of options, a panel of eight subject matter experts concluded that filling the tunnel with grout was the preferred stabilization method. Other options included covering the tunnel with tarps, tents, or more permanent structures; collapsing the tunnel in place; and filling the tunnel with sand, clay, grout, or expanding foam.

According to the DOE, the grouting of Tunnel 2 is expected to begin before the end of the current fiscal year, Sept. 30, 2018, allowing time to incorporate the lessons learned from the grouting of Tunnel 1. The schedule also will allow for the development of work controls and design, as well as the consideration of seasonal conditions for grout placement.

The AY-102 Recovery Project received the 2017 Project of the Year Award at PMI's Global Conference in October. Pictured, from left, are Caterina La Tona, vice chair of PMI's board of directors, Sebastien Guillot, AY-102 Recovery Project manager, Doug Greenwell, WRPS Retrieval manager, and Mark Dickson, chairman of the PMI board. (Photo: WRPS)

● The Project Management Institute (PMI) has awarded Washington River Protection Solutions (WRPS) the 2017 PMI Project of the Year Award for its work to remove high-level radioactive waste from an underground storage tank at the Hanford Site. The award recognizing Hanford's Double Shell Tank AY-102 Recovery Project was presented to WRPS at PMI's Global Conference 2017, held Oct. 28–30, 2017, in Chicago, Ill.

The AY-102 Recovery Project involved the transfer of waste from the leaking tank to another double-shell tank, AP-102. WRPS, the Department of Energy's tank operations contractor at the Hanford Site, completed the recovery of the tank's 725,000 gallons of nuclear waste ahead of schedule and $8.7 million under budget. According to PMI, WRPS had a 15 percent chance of success at the start of the project.

WRPS also received a PMI Award for Project Excellence for its AP Tank Farm exhauster upgrade project at Hanford. The project involved the design, fabrication, and installation of a new ventilation system for the eight waste tanks at the AP Tank Farm. The work was completed in 2016 to enable the AP Tank Farm to receive, stage, and transfer millions of gallons of waste to Hanford's Waste Treatment and Immobilization Plant for vitrification.

● The Department of Energy announced on Nov. 21, 2017, that Washington River Protection Solutions is wrapping up waste retrieval activities at the last tank at the site's C Tank Farm.

According to the DOE, WRPS removed radioactive and chemical waste from the C-105 underground waste storage tank to the limits of three technologies, leaving an estimated residual waste volume of 4,800 gallons in the tank. C-105, a single-shell tank, is the 16th and final tank at Hanford's C Farm to undergo waste retrieval under legal agreements governing cleanup activities at Hanford between the DOE and the Washington Department of Ecology. C Farm was one of four Hanford tank farms constructed during the Manhattan Project.

Approximately 120,000 gallons of waste was removed from C-105, which has a capacity of 530,000 gallons, and transferred to a double-shell tank. Under the DOE's agreement with the state of Washington, residual waste in large tanks, such as C-105, is not to exceed 360 cubic feet (about 2,700 gallons), or the limit of capability using current waste retrieval technology. With all of the retrievable waste removed, workers will finish video measurements and sampling of the residual waste.

WIPP

Waste Control Specialists (WCS) will continue to store transuranic (TRU) waste from Los Alamos National Laboratory (LANL) at its Andrews County, Texas, facility under a two-year, $19-million contract with the Department of Energy's Environmental Management Los Alamos Field Office. Among the 230 drums of TRU waste, which were packaged at LANL and intended for permanent disposal at the Waste Isolation Pilot Plant, are more than 100 drums containing nitrate salt waste, like the drum that was the source of the radiological release at WIPP in February 2014.

Following the 2014 salt truck fire and radiological release at WIPP, shipments of TRU waste to the repository were suspended while recovery work was being performed. (WIPP resumed accepting waste shipments in April 2017.) To meet deadlines with the state of New Mexico, however, LANL began shipping TRU waste to the WCS facility for temporary storage. Those shipments stopped when it was discovered that some of the waste contained the organic kitty litter that was determined to have caused the exothermic reaction in the drum disposed of at WIPP.

According to a Sept. 27, 2017, press release from WCS, the contract replaces a previous subcontract between WCS and DOE contractor Nuclear Waste Partnership, which operates WIPP, and consists of two task orders. The first order is for the continued storage of the TRU waste drums, along with mobile loading support upon removal. The second covers ancillary activities regarding the stored TRU waste, including WCS's support of the DOE and its contractor in the development of a feasibility study of various methods for the transport and ultimate disposal of the waste.

Under an exemption order issued by the Nuclear Regulatory Commission in December 2014, WCS was permitted to store the LANL waste for two years. In September 2016, at the request of WCS, the NRC gave WCS a two-year extension, allowing the company to store the waste until Dec. 23, 2018. The waste is to be shipped to WIPP once the DOE completes the transportation feasibility study.

● Salt mining operations resumed at the Waste Isolation Pilot Plant in January after a four-year interruption. Mining in the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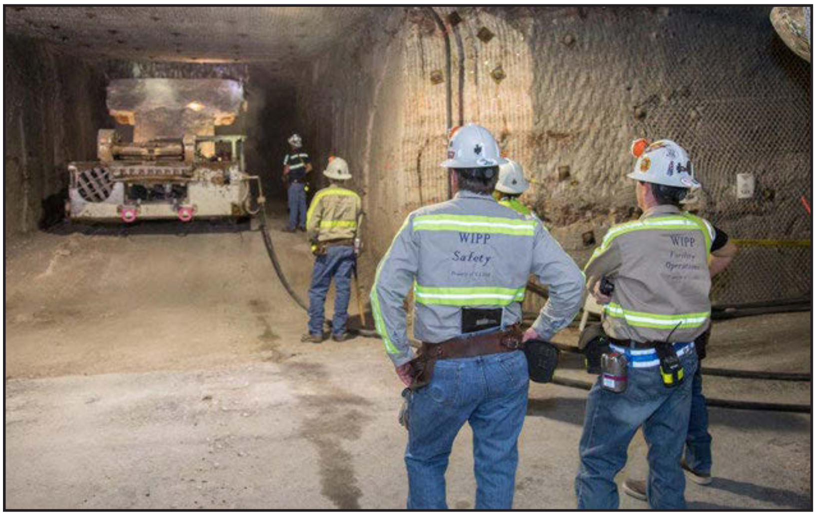


Mining of Panel 8 in the DOE's Waste Isolation Pilot Plant in New Mexico was resumed in January. (Photo: DOE)

underground of the WIPP was restarted in Panel 8, which will be used for the emplacement of transuranic waste once Panel 7 of the geologic repository is filled. The mining of Panel 8 began in late 2013, but was halted following the separate fire and radiological events in 2014 that suspended waste operations. More than 112,000 tons of salt will be removed from the underground to complete the panel, which will contain seven disposal rooms. Each room is 300 feet long, 33 feet wide, and 13 feet high. Completion of Panel 8 is scheduled for 2020.

Used nuclear fuel

The Nuclear Regulatory Commission has approved Dominion Generation's license amendment application for the North Anna independent spent fuel storage installation (ISFSI), part of a study on dry storage of high-burnup spent nuclear fuel. Notice of the approval of the license amendment, which will allow Dominion to store high-burnup spent fuel assemblies in a modified Areva TN-32B cask at the North Anna nuclear power plant near Mineral, Va., was published in the Sept. 21, 2017, *Federal Register.*

Sponsored by the Department of Energy and the Electric Power Research Institute (EPRI), the High Burnup Dry Storage Cask Research and Development Project, launched in 2013, is intended to gather data on the effects of long-term dry storage on high-burnup fuel assemblies (greater than 45 gigawatt days per metric ton of uranium). EPRI is leading a project team to develop and implement a test plan to collect the data. In addition to validating and improving current predictive models, the test will provide input to future dry storage cask design and will support ISFSI license renewals and new licenses and transportation licensing for high-burnup spent fuel.

The high-burnup fuel will be taken from North Anna's spent fuel pool, and the loaded cask will be moved to the plant's ISFSI, where it will be monitored for 10 years or more. About 25 "sister" fuel rods have already been removed from North Anna and sent to Oak Ridge National Laboratory, where they will be examined and compared with the TN-32B assemblies at the conclusion of the project.

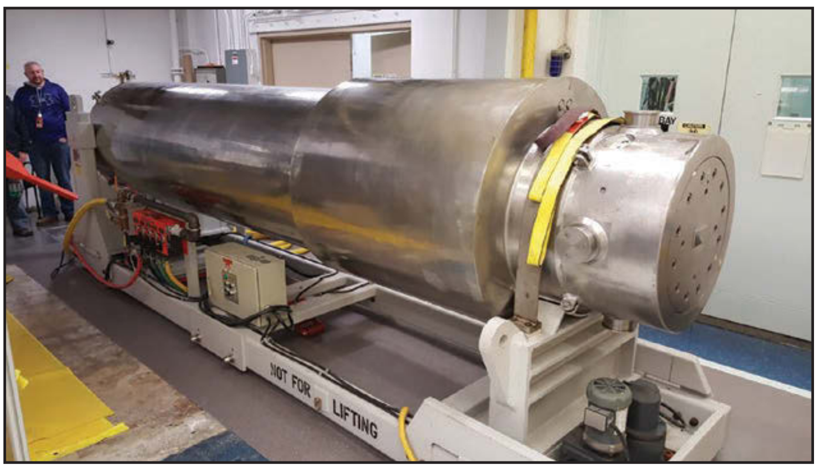
● A coalition of six organizations on Oct. 23, 2017, sent a joint letter to the leaders of the U.S Senate and House of Representatives, asking that Congress appropriate funds for fiscal year 2018 to ensure that the Department of Energy honors its commitments under the Nuclear Waste Policy Act (NWPA) and contracts with utilities to remove and dispose of used nuclear fuel and high-level radioactive waste currently stored at operating and shutdown nuclear reactor sites and federal facilities.

The letter was signed by Robert Coward, president of the American Nuclear Society and a principal officer of MPR Associates; Maria Korsnick, president and chief executive officer of the Nuclear Energy Institute; Wayne Norton, chair of the Decommissioning Plant Coalition's Steering Committee and president and CEO of Yankee Atomic Electric Company; David Blee, executive director of the Nuclear Infrastructure Council; John Betkoski, president of the National Association of Regulatory Utility Commissioners and vice chairman of the Connecticut Public Utilities Regulatory Authority; and Sarah Hoffman, chair of the Nuclear Waste Strategy Coalition and a commissioner on the Vermont Public Utility Commission.

The coalition said that it is "absolutely essential" that Congress act now to fund the completion of the Yucca Mountain licensing process, and that this action would send a clear message that the federal government is committed to ensuring that the DOE carries out its statutory responsibility to manage and dispose of used nuclear fuel and HLW. The coalition also asks that funding be approved to implement a pilot consolidated interim storage facility for stranded spent fuel and greater-than-Class C waste, and to help prepare for the movement of used fuel and HLW through the development of the necessary transportation infrastructure.

● The Overseas Private Investment Corporation, a self-sustaining U.S. government agency that helps American businesses invest in emerging markets, is providing $250 million in "political risk insurance" to Ukraine's Energoatom for the construction of the Central Spent Fuel Storage Facility (CSFSF). A signing ceremony for the project was hosted by the government of Ukraine on Dec. 21, 2017.

The State Nuclear Regulatory Inspectorate of Ukraine issued a license in July 2017 to Energoatom to construct and commission the CSFSF in the Chernobyl Exclusion Zone for the interim storage of used fuel from three of Ukraine's four nuclear power plants. According to Holtec International, which



The shipping cask with "sister" fuel rods after it arrived at Oak Ridge National Laboratory in early 2016. Researchers will compare the physical state of the sister rods with the rods inside the modified Areva TN-32B dry storage cask after a decade of storage. (Photo: DOE/ORNL)

is supplying its HI-STORM dry cask storage system and other equipment for the facility, the CSFSF will begin accepting used fuel in 2019.

According to OPIC, the 20-year loan will be financed by Bank of America/Merrill Lynch, which is arranging for the sale of OPIC's $250-million commitment in the U.S. capital markets in the form of fixed-rate bond securities. The Ukraine government will repay the loan through the issuance of a sovereign guarantee.

● China National Nuclear Corporation (CNNC) announced on Dec. 22, 2017, that a prototype unit of the company's Longzhou-CNSC used nuclear fuel shipping container has passed the acceptance test and is ready for batch production. According to the company, passing the acceptance test signifies that CNNC has succeeded in developing a large-scale used fuel shipping container, filling a technology gap in China for used fuel management and marking a milestone for the country's nuclear program. The Longzhou-CNSC container can hold 21 sets of used fuel assemblies.

● Licensing of a used nuclear fuel repository at Forsmark, Sweden, has been recommended by the Swedish Radiation Safety Authority (SSM), which on January 23 submitted to the Swedish government the findings of its regulatory review of the Swedish Nuclear Fuel and Waste Management Company's (SKB) license application for the deep geologic repository, along with a license for a separate encapsulation facility.

SKB submitted in 2011 its license applications for the repository at Forsmark on the east coast of central Sweden and the encapsulation facility in the Oskarshamn Municipality on the country's southeast coast. According to SSM, SKB has demonstrated through its license applications and associated safety analysis reports that the facilities can be developed in accordance with Swedish law and with the protection of human health and the environment.

Sweden's Land and Environment Court, Nacka District, however, issued a statement the same day claiming that more technical information is needed on the copper capsules used to contain the used fuel. According to the court, there are significant uncertainties about the capsules that have not been taken into account in SKB's safety analysis. The court said that, based on SKB's analysis, it cannot confirm the long-term safety of the repository without additional documentation clarifying that the repository is safe even in the case of the capsule's protective capability. The government of Sweden will consider granting the licenses based on the recommendations of SSM and the court.

● Canada's Nuclear Waste Management Organization (NWMO) completed borehole drilling near Ignace, Ontario, in January. The drilling to obtain initial core samples and provide access to the rock at depth is part of the NWMO's investigation into suitable sites for a deep geologic repository for Canada's used nuclear fuel.

According to the NWMO, drilling started on Nov. 6, 2017, in a rock formation known as the Revell Batholith, located south of Highway 17, about 35 kilometers (about 22 miles) west of Ignace (between Ignace and Wabigoon Lake Ojibway Nation). Ignace is one of five regions in Ontario the NWMO currently is studying as potential repository host sites. The other regions include the areas around the communities of Huron-Kinloss, South Bruce, Hornepayne, and Manitouwadge.

The NWMO hopes to identify a potential repository site with a suitable rock formation in an area with an informed and willing host. The NWMO expects to be able to select the preferred site for detailed site characterization by about 2023. Further activities to analyze the core samples and explore the borehole at depth are now underway, the NWMO said.

Low-level waste

The International Atomic Energy Agency has launched an initiative to manage disused radioactive sources. The IAEA announced on Sept. 19, 2017, that it has introduced the concept of qualified technical centers for the safe and secure management of used sealed sources. Radioactive sources are used in various devices at medical, industrial, and agricultural facilities, and disused sealed radioactive sources (DSRS) make up much of the radioactive waste arising from nuclear applications. Christophe Xerri, director of the IAEA's Division of Nuclear Fuel Cycle and Waste Technology, said in a statement, "The idea behind this initiative is to increase the worldwide capability to manage DSRS by encouraging countries with well-equipped centers and trained personnel to provide technical services for the management of DSRS, within their countries and regionally."

● Canadian Nuclear Laboratories (CNL) announced on Nov. 24, 2017, that it has requested an amended timeline for its Near Surface Disposal Facility project at the Chalk River Laboratories in Ontario. CNL said that it is working with the Canadian Nuclear Safety Commission (CNSC) to establish a revised schedule for final regulatory submittals, including the submission date for the facility's final environmental impact statement (EIS) for the low-level radioactive waste facility.

CNL submitted a draft EIS for the project to the CNSC and released it for public review in March 2017. CNL said that it has received more than 200 public comments and federal technical submissions on the draft EIS, along with requests for additional information from the CNSC. To provide time to respond to those submissions and to complete a third-party review, CNL said that the schedule for final EIS submittal and the licensing hearing will need to be extended. According to CNL, the organization is currently responding to comments to the draft EIS and, subject to their acceptance by the CNSC, will update and finalize the EIS as set out under an amended project schedule.

CNL announced on Oct. 26, 2017, that it has decided to include only low-level radioactive waste in the facility based on comments it received on the draft EIS. CNL will continue to manage intermediate-level waste in interim storage at Chalk River until a long-term disposal solution for that waste category has been developed and approved.

D&D

The Nuclear Regulatory Commission has published a final regulatory basis in support of its proposed rulemaking for the decommissioning of commercial nuclear power reactors. Notice of the regulatory basis was published in the Nov. 27, 2017, *Federal Register*.

The decommissioning rulemaking is intended to improve regulations for reactors that are transitioning to decontamination and decommissioning, providing for a more efficient D&D process and reducing the need for exemptions from existing regulations. The NRC issued an advance notice of proposed rulemaking in November 2015, followed by a draft regulatory basis in March 2017. The NRC staff considered public comments received during both stages in preparing the final regulatory basis.

In the regulatory basis, the NRC staff concluded that there is sufficient justification to proceed with new regulations in the areas of emergency preparedness, physical security, cybersecurity, drug and alcohol testing, training requirements for certified fuel handlers, decommissioning trust funds, off-site and on-site

financial protection requirements and indemnity agreements, and application of the backfit rule. The NRC staff is also recommending that reporting and documentation requirements be clarified in the areas of spent fuel and low-level radioactive waste management; structures, systems, and components; and environmental reporting requirements.

The regulatory basis also reiterates the NRC's conclusions that regulatory activities other than rulemaking—such as guidance development—can be pursued to address the appropriate role of state and local governments in the D&D process, the level of NRC review of the post-shutdown decommissioning activities report, and the 60-year limit for power reactor decommissioning. In addition to the regulatory basis, the NRC staff plans to issue a revised preliminary draft of the regulatory analysis, which will update and refine the analysis of costs and benefits.

The NRC plans to publish a proposed decommissioning rule for public comment in 2018.

● The Nuclear Regulatory Commission published notice in the Oct. 6, 2017, *Federal Register* that it is discontinuing its prompt remediation rulemaking activities. As a result of the NRC's evaluations and stakeholder interactions, the agency said it will no longer pursue changes to regulations in 10 CFR Part 20 to require licensees to remediate, during facility operations, releases of residual radioactivity into the surface and subsurface of their facility sites.

The NRC began studying the potential need for a prompt remediation rulemaking in 2007. Based on the staff's evaluation of how licensees are complying with current regulations, however, the NRC commissioners determined that licensees are operating their facilities to minimize leaks and spills, monitoring for residual radioactivity, adjusting decommissioning funding to account for residual surface and subsurface radioactivity, and maintaining doses to the public within regulatory limits.

● A contaminated Air Force building in Georgia will be decommissioned under a plan likely to be approved by the Nuclear Regulatory Commission. As published in the Sept. 19, 2017, *Federal Register*, the NRC has issued an environmental assessment and finding of no significant impact regarding the plan submitted by the Department of the Air Force for decommissioning Building 181 at the Robins Air Force Base, about 18 miles south of Macon, Ga.

If the NRC approves the plan, the Air Force will remediate residual depleted uranium from inside and underneath Building 181, reducing the residual radioactivity to levels that will allow the property to be released for unrestricted use. Based on its assessment, the NRC said that it plans to approve the proposed decommissioning plan by amending the Air Force's nuclear materials license.

● The Canadian Environmental Assessment Agency announced on January 5 that federal and provincial authorities have reviewed the draft environmental impact statement (EIS) for the decommissioning of the Whiteshell Reactor 1 (WR-1). Canadian Nuclear Laboratories (CNL) is proposing an *in situ* approach to the decommissioning of WR-1, a research reactor located at the Whiteshell Laboratories site in Pinawa, Manitoba, that operated until 1985.

The project's environmental review is being carried out by the Canadian Nuclear Safety Commission (CNSC), which has identified a number of areas where additional information will need to be included in the final EIS and other technical supporting documentation. The CNSC staff's assessment is reflected in a series of comments that have been consolidated with those of other federal and provincial authorities participating in the review. CNL will address all of the comments before submitting a final EIS to the CNSC, which will then make a determination as to whether the information provided is complete.

● Korea Hydro & Nuclear Power Company (KHNP) announced on Dec. 10, 2017, that it plans to ramp up the development of decontamination and decommissioning technologies. The South Korean company said that given changing policies both in South Korea and abroad that are leading to the early closure of nuclear power plants, the company is hoping to enter the global nuclear D&D market.

Citing industry sources and data, the company said that the global nuclear D&D market is expected to be worth more than $366 billion in the future. KHNP is currently overseeing the decommissioning of South Korea's Kori-1 nuclear reactor, which was shut down in June 2017 after 40 years of commercial operation. The company said that it has secured 39 of the 56 decommissioning technologies required to dismantle the reactor and is on track to develop the rest. KHNP has been forming partnerships with companies outside of South Korea to acquire decommissioning capabilities.


A nonradiological site restoration fund for the closed Vermont Yankee nuclear power plant was created as part of a settlement agreement with the state of Vermont.

Vermont Yankee

A Vermont Yankee site restoration fund created as part of a 2013 settlement agreement between Entergy and the state of Vermont is now worth approximately $31 million, following Entergy's final deposit of $5 million into the fund on Dec. 21, 2017. Separate from the plant's decommissioning trust fund, the site restoration fund was established for the nonradiological cleanup of the Vermont Yankee site. Plant owner Entergy permanently ceased operation of the Vermont Yankee nuclear power plant, a single-unit boiling water reactor, in December 2014.

The settlement agreement resolved ongoing litigation between the state and Entergy following the company's announcement in August 2013 that it was closing the plant because of economic factors. In exchange for the state dropping its lawsuits and supporting the plant's operation through 2014, Entergy agreed to

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set aside $25 million to restore the Vermont Yankee site for unrestricted use after the plant is decommissioned. Entergy made an initial payment of $10 million into the site restoration fund, followed by three additional payments of $5 million in 2015, 2016, and 2017. The fund's current value is a result of investment growth, according to Entergy.

● The Nuclear Regulatory Commission issued a final environmental assessment (EA) and finding of no significant impact (FONSI) for two exemptions that will allow Entergy to use Vermont Yankee's decommissioning funds for the management of the reactor's spent nuclear fuel. Notice of the EA and FONSI was published in the Dec. 26, 2017, *Federal Register*.

The NRC had approved the regulatory exemptions from sections 50.82(a)(8)(i)(A) and 50.75(h)(1)(iv) of 10 CFR Part 50 in June 2015. The state of Vermont, along with former plant owners Vermont Yankee Nuclear Power Corporation and Green Mountain Power Corporation, challenged the exemptions, and the commissioners directed the staff to conduct an EA to examine the environmental impacts, if any, associated with the exemptions.

In requesting the exemptions, Entergy said that it needed access to decommissioning trust funds to support irradiated fuel management activities not associated with radiological decommissioning. Based on the EA and FONSI, the NRC concluded that the exemptions will not have a significant effect on the quality of the human environment. As a result of its findings, the NRC has determined that it will not prepare an environmental impact statement regarding the exemptions.

Environmental remediation

The Nuclear Regulatory Commission has agreed to retain regulatory authority over the site of a defunct uranium mill in Wyoming as part of the state's application to become an NRC Agreement State. The three sitting commissioners on Oct. 4, 2017, voted unanimously to approve the NRC staff's recommendation to retain authority over the American Nuclear Corporation (ANC) site in Gas Hills, Wyo. The ANC mill, which operated from 1960 through 1982, is currently regulated by the NRC under Title II of the Uranium Mill Tailings Radiation Control Act.

In its draft application to become an NRC Agreement State, submitted in October 2016, Wyoming had requested that the NRC retain authority over the ANC site and five other uranium mining and milling sites. According to the NRC, excluding the six sites would have deviated from the agency's policies and resulted in the state and the NRC having regulatory authority over different sites with the same category of materials and activities.

The NRC staff recommended that the NRC retain authority over the ANC site, with Wyoming assuming responsibility for the other five sites. While the exclusion would be inconsistent with 30 years of NRC policy, the agency staff noted that the conditions surrounding the site—no viable licensee and insufficient remaining decommissioning funds—made it a unique case. The staff also argued that the NRC's retaining authority over the ANC site would be consistent with a 1996 confirmatory order with the state in which the NRC agreed not to require Wyoming to pay for any reclamation, remediation, monitoring, or surveillance work at the site above what is available in the decommissioning fund.

● A €210-million (about $248-million) plan for remediating uranium legacy sites in Central Asia was signed by the International Atomic Energy Agency, the European Commission (EC), and the European Bank for Reconstruction and Development (EBRD) on the sidelines of the 61st IAEA

A plan to remediate uranium legacy sites, such as this abandoned uranium mill at Taboshar, Tajikistan, was signed by the IAEA, the European Commission, the European Bank for Reconstruction and Development, and Central Asian countries. (Photo: Peter Waggit/IAEA)

General Conference, held Sept. 18–22, 2017, in Vienna.

The Strategic Master Plan, which provides a framework for carrying out remediation activities in Central Asia, was also signed by Tajikistan and Uzbekistan, two of the three countries that are in the scope of the EBRD's environmental remediation account for Central Asia. According to the EBRD, the third country, the Kyrgyz Republic, has confirmed its intention to join the plan, as has Russia.

Developed on behalf of the Central Asian countries by members of the IAEA's Coordination Group for Uranium Legacy Sites, the plan is intended to ensure that the remediation of uranium mining sites will be done in a timely, coordinated, cost-effective, and sustainable manner and in accordance with relevant international conventions and agreements. It also sets out an integrated approach for evaluating the remediation needs of each site. Much of Central Asia's uranium mining and processing ceased in the 1990s, leaving numerous sites containing uranium waste and other radioactive processing wastes in densely populated areas.

● According to a study performed at the abandoned South Terras Mine in Cornwall, England, arsenic may be effective in preventing uranium migration in the environment. Carried out by an international team led by the Department of Materials Science and Engineering at the University of Sheffield, the study found that uranium combines with arsenic to form the complex and highly insoluble mineral metazeunerite, which was found in the topsoil at the mine.

According to the University of Sheffield, the study has far-reaching implications, from the remediation of abandoned uranium mines to the environmental cleanup of nuclear accidents and legacy waste sites, and shows the importance of local geology on the behavior of uranium. The study, "Multi-Scale Investigation of Uranium Attenuation by Arsenic at an Abandoned Uranium Mine, South Terras," was published online in *Nature Partner Journals* and can be found at www.nature.com/articles/s41529-017-0019-9.

DOE updates

The Department of Energy announced on Dec. 19, 2017, that it has awarded a five-year, $1.39 billion Los Alamos cleanup contract to the consortium Newport News Nuclear BWXT–Los Alamos. The Los Alamos National Laboratory (LANL) legacy waste cleanup contract, which provides for two additional option periods totaling five years, primarily includes a cost-plus-award-fee line item with a cost-reimbursement line item for a 90-day transition period and an indefinite-delivery, indefinite-quantity line item, according to the DOE.

The consortium will take over work currently performed by Los Alamos National Security, whose contract with the DOE's Office of Environmental Management (EM) expires on March 31, 2018. Under the new contract, Newport News Nuclear BWXT-Los Alamos will clean up contaminated legacy waste sites at LANL, decontaminate and decommission inactive facilities, and package and ship legacy mixed low-level radioactive and transuranic waste for off-site disposal. The company will also protect and monitor the regional aquifer and return cleaned sites to the National Nuclear Security Administration for long-term surveillance and monitoring. EM took over the management of legacy waste cleanup at LANL from the NNSA in 2014 following the accidents at the Waste Isolation Pilot Plant.

● The Department of Energy announced on Nov. 7, 2017, that it has finished treating 60 drums of remediated nitrate salts (RNS) at Los Alamos National Laboratory. The work was conducted by the DOE's Office of Environmental Management and National Nuclear Security Administration field offices at Los Alamos and contractor Los Alamos National Security.

The drums contained an incompatible combination of nitrate salt waste mixed with organic cat litter, which was added during repackaging to absorb liquids and to neutralize the combustible characteristic of the nitrate salts. The drums needed to be treated to allow for their safe disposition at the Waste Isolation Pilot Plant. An RNS drum from LANL was the cause of the February 2014 radiological event at WIPP.

Treatment of the RNS waste stored at LANL, which began in May, involved removing the waste from the drums and mixing it with water and zeolite, an inert material, to render the waste nonreactive. The treated waste was repackaged into new drums, which are being stored at LANL. The drums will undergo certification to ensure that they meet WIPP's revised waste certification criteria before being shipped to the transuranic waste repository.

LANL technicians practiced and refined the method for treating remediated nitrate salts using a mock-up glovebox closely resembling the glovebox used during the actual treatment. (Photo: DOE)

● The acceptance and disposition of used nuclear fuel from Germany at the Department of Energy's Savannah River Site (SRS) in South Carolina would have little or no impact on the health and safety of the public or the environment, according to the DOE, which on Dec. 20, 2017, issued an environmental assessment and finding of no significant impact for the proposed action. In line with the U.S. government's nonproliferation efforts, the DOE is considering accepting the used fuel, which contains about 900 kilograms (1,980 pounds) of U.S.-origin high-enriched uranium, from Germany for processing and eventual disposal.

The used fuel is in the form of small graphite pebbles containing varying quantities of uranium and thorium, with uranium enrichments up to 81 percent. The United States provided the HEU to Germany under the Atoms for Peace program between 1965 and 1988. The fuel was irradiated at the Arbeitsgemeinschaft Versuchsreaktor reactor and the Thorium High Temperature Reactor-300 as part of a research and development program for the pebble bed high-temperature gas-cooled reactor technology. Approximately 1 million pebbles are currently in storage in 455 CASTOR casks at Jülich and Ahaus, Germany.

Under the proposed action, the used fuel would be transported in chartered ships across the Atlantic Ocean to Joint Base Charleston–Weapons Station, near Charleston, S.C. From there, the CASTOR casks would be transported by train to SRS, where they would be unloaded and placed in secure storage. The used fuel would be processed and the resulting waste forms, including the uranium, would be disposed of or stored until an appropriate disposal facility is available.

● A new Savannah River Site waste melter has begun operations. The first canister of vitrified radioactive waste from Melter 3 was poured on January 1. The melter was installed at SRS's Defense Waste Processing Facility in June 2017 and is only the third melter in the facility's 20-year history. The 75-ton teapot-shaped melter treats high-level radioactive liquid waste by blending it with a borosilicate glass to form a molten glass mixture, a process known as vitrification. The mixture is poured into stainless steel canisters that are stored on-site until a permanent disposal facility is available. As of January 9, Melter 3 had poured seven canisters of vitrified waste.

● The Department of Energy broke ground in November 2017 on the Mercury Treatment Facility at the Y-12 National Security Complex in Oak Ridge, Tenn., paving the way for large-scale cleanup and demolition at the site. Sen. Lamar Alexander (R., Tenn.), Rep. Chuck Fleischmann (R., Tenn.), Tennessee Deputy Gov. Jim Henry, DOE Deputy Secretary Dan Brouillette, and Jim Owendoff, principal deputy assistant secretary of the DOE's Office of Environmental Management, attended the groundbreaking ceremony on Nov. 20, 2017.

Constructed during the Manhattan Project to explore uranium enrichment, Y-12 began lithium separation for weapons production during the 1950s and 1960s. The separations process required large amounts of mercury, which flowed through pumps, pipes, valves, and seals at high rates. An estimated 700,000 pounds of mercury was lost into the equipment, buildings, and surrounding soil.

The DOE said that mercury cleanup is its top priority at Y-12 and that the new facility will allow for the demolition of the four major mercury-use facilities at the site, the Alpha-2, Alpha-4, Alpha-5, and Beta-4 buildings, which date to the 1940s and have deteriorated. After the buildings are removed, the DOE will remediate the underlying soil. The DOE anticipates that the facility will begin operations in 2022. ■

Manufacturing Millennials

Introducing a new generation to the rewards of working with one's hands.

By Rob Despain

At a very young age I was exposed to manufacturing by my father, who was a metal shop teacher at a local junior high. Growing up, we were always building or making something with our hands. During that era I realized that manufacturing, or building something, was fun and that there was a real sense of accomplishment when you were done. You were able to stand back and look at your work—good, bad, or indifferent—and see what you had created.

Today I find myself serving as the past chairman of the board of the Utah Manufacturers Association, as well as being employed by Petersen Inc., one of the country's leading manufacturers of custom fabrication and precision machined products. My role with Petersen today is as vice president of business development, where I get to be a part of manufacturing and creating everything from rocket motors to roller coasters on a daily basis. In addition to mining instruments and oil and gas equipment, Petersen also manufactures nuclear-related equipment, including glove boxes, casks, process equipment, containers, and containment vessels. It is a fun, diversified environment in which to be able to stand back and see what we have accomplished as a team.

Despain

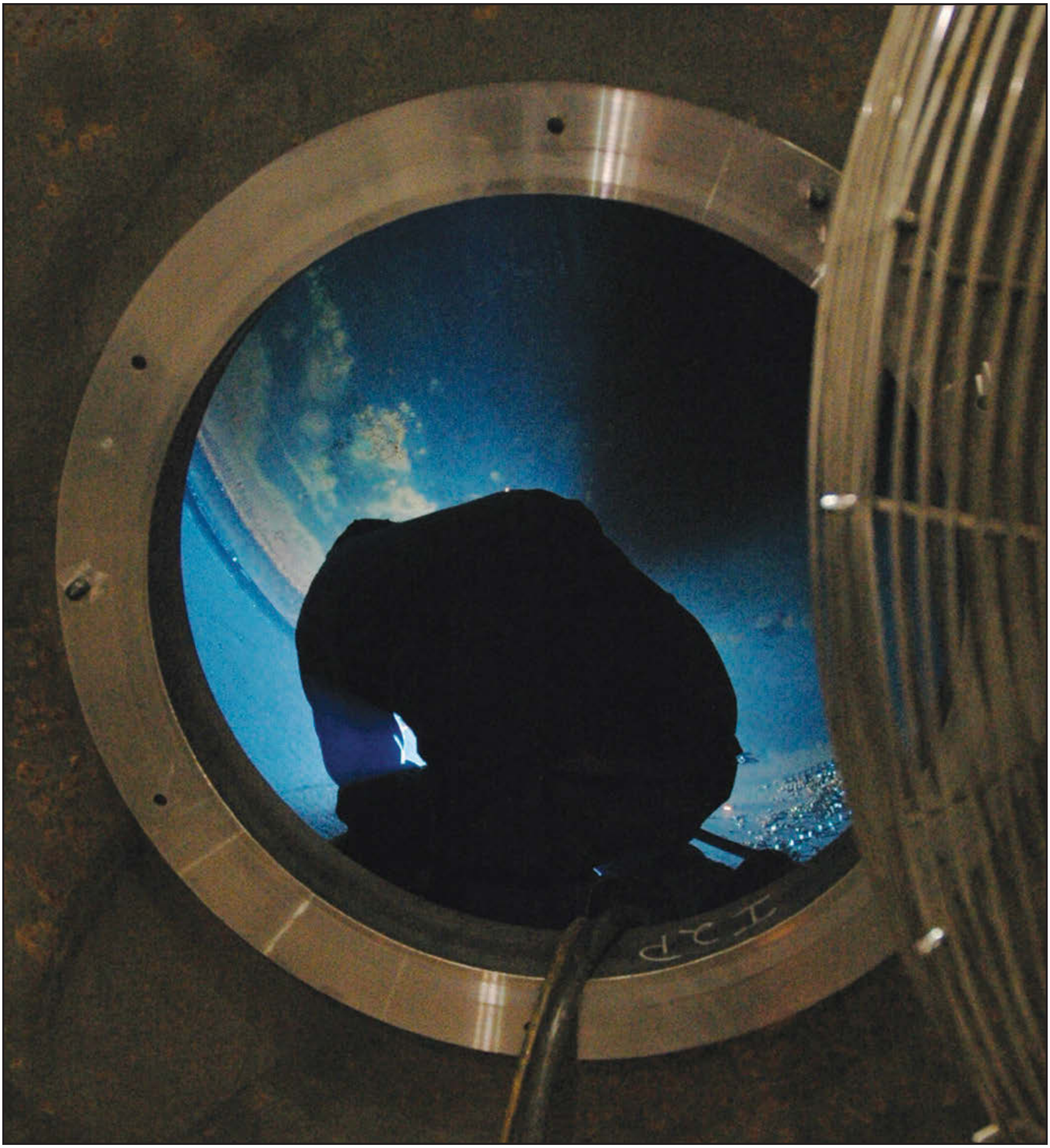
More than three decades ago, when I joined Petersen, I was by today's standards a millennial (someone 35 years of age and under). Manufacturing has shaped my life in a fashion that I can honestly say I have no regrets. If I had to choose again, I wouldn't choose anything different. People continue to choose every day what career path they are going to follow and what opportunities suit them best. Recently, the Utah Manufacturers Association launched a workforce development campaign targeting the millennial age group. This will prove to be vital to the success of our aging manufacturing companies and workforce. Those companies that embrace "manufacturing millennials" are going to be the cutting-edge companies that survive and thrive in tomorrow's manufacturing environment.

The current manufacturing climate is much different than it was in my dad's shop, or the company I went to work for 34 years ago. Today, we find ourselves looking for ways to do it safer, faster, and more affordable. We have to be incredibly efficient while producing high-quality goods and services to the industries we serve. The manufacturing industry is filled with uncertainty. Foreign competition, the ebbs and flows of the nuclear industry, finding a skilled workforce, retaining a skilled workforce, and the U.S. economy are just a few of the challenges we are faced with on a daily basis. To offset those challenges we need to continue to invest in our workforce, in the modernization of our facilities, and embrace today's technologies, including social media. Millennials live in a tech-savvy social media world. That is how we are going to attract them and get them to slow down long enough to take a look at manufacturing.

I find myself spending time and investing resources at elementary, junior high, high school, and vocational colleges and universities, educating students, teachers, and counselors about manufacturing. There has always been, and there will always be, those who want to work with their hands, whether it is old-school building, or today's world of programming, automation, and running computer numerical control (CNC) equipment. All of these require problem-solving skills and the ability to see and find solutions. These skills are vital to the industry and create meaningful opportunities to build a career. At Petersen, we have invested in and endorsed the STEM (science, technology, engineering, and mathematics) initiative that is sweeping the country. We believe it is the only way we are going to be able to compete at home and abroad.

Why should manufacturers invest both financially and educationally in the future generations? For ourselves, we know we can't draft 12 math-loving 5th-graders and route them into the company when they graduate, but if, because of their exposure to it, they consider manufacturing as a viable option for a career plan, then we are investing in the future of manufacturing. It reminds me of the old adage that all boats float on a rising tide. Time, money, and resources invested in the future generation will benefit us all in our pursuit of skilled team members who will have a previous knowledge of manufacturing. Think about this: Who is going to replace you? Do you have a succession plan?

As manufacturing professionals, if we don't tell our story and make our facilities available to the education system, how will they know the incredible opportunities and the diversity of opportunities that exist in manufacturing today? It is important that they know that manufacturing provides high-paying, safe jobs and incredible career opportunities for those who are



A welder completes fabrication of a piece of equipment. Getting younger people interested in manufacturing involves reaching out to them and showing them what is possible.

willing to invest the time in their own careers.

That is not to say that manufacturing does not have its challenges. The current global economic situation is changing every day and is very uncertain. I think the new normal in manufacturing is uncertainty, and now would be a good time to realize that there is no such thing as normal. Normal doesn't exist in life or in manufacturing. Normal is overrated. Uncertainty, on the other hand, provides opportunity. It provides growth. It forces us to change—to be leaner, to become better manufacturers, to never get caught with all our eggs in one basket, and to continually look for ways to rebrand, differentiate, and diversify our manufacturing portfolios.

Every day each of us is faced with many challenges as well as many opportunities. It all depends on perspective. I choose to see things from a "glass half full" point of view. Manufacturing is changing, progressing, and evolving, but hopefully so are we.

In closing, it is a great time to be a manufacturer and a great time to be in the manufacturing business. Whether we are manufacturing fabricated and machined products or manufacturing our future workforce, the future is bright for manufacturing throughout the United States. Petersen manufactures in a leading economic state in the nation. Our current administration is supporting manufacturing and "Made in America." These are even more reasons to stay involved in manufacturing millennials. ■

Baselining a Spent Nuclear Fuel Cask Shielding Model

By Riley Cumberland and Kaushik Banerjee

Radiation dose analysis is essential for the safe handling, storage, transportation, and disposal of any spent nuclear fuel (SNF) cask. Not only must nuclear facility designers and operators meet the regulatory dose limits for workers and the general public mandated by the U.S. Nuclear Regulatory Commission, they also must perform evaluations to support design and operational decisions to show that radiation doses are as low as reasonably achievable (ALARA).

For SNF casks, shielding calculations are performed primarily to determine dose rates outside a given system. These dose rate calculations are typically conservative due to simplified analysis premises, such as modeling an SNF cask with bounding radiation source terms (e.g., maximum burnup and minimum cooling time). Source terms with bounding parameters such as burnup also are typically evaluated using simplified reactor operating histories to maximize the gamma and neutron sources.

While this conservative dose analysis approach is acceptable for designing an SNF cask to provide safety to the public, this conservative analysis approach also creates a variety of operational challenges. For instance, this approach may result in a demand for supplementary shielding during loading, overly complex loading procedures to maintain ALARA, and decades of additional cooling time before SNF can be considered transportable. Thus, a reliance upon conservative shielding analyses could conceivably limit when a standalone independent spent fuel storage installation (ISFSI), used for the dry storage of SNF, would be able to ship SNF off-site and the ISFSI land be returned to unrestricted use.

Although the benchmarking of any shielding analysis software code is essential from the code development perspective, shielding code benchmarking is not typically used to support SNF cask licensing due to the conservative nature of the shielding analysis. Plant operators rely on actual dose measurements to ensure that the system's behavior is as per the design basis dose analysis. The measured dose rates should always be much lower than the calculated dose rates, sometimes by orders of magnitude.

More accurate computation of dose rates can provide additional flexibility for both facility designers and operational planners. Detailed analyses producing realistic dose rates can be used to 1) determine the actual earliest time casks are transportable, and 2) gather better estimates of dose to the public during large-scale campaigns for transporting SNF from ISFSIs to an interim storage location and/or to a disposal facility.

UNF-ST&DARDS

The Used Nuclear Fuel-Storage, Transportation & Disposal Analysis Resource and Data System (UNF-ST&DARDS) is being developed at the Oak Ridge National Laboratory (ORNL) as a foundational resource for the Department of Energy's Office of Nuclear Energy to streamline computational analysis, thereby facilitating time-dependent characterization of SNF and related systems [1]. UNF-ST&DARDS automates the prediction of the state of SNF far into the future using a range of analyses, including isotopics, shielding, criticality, and thermal analyses. The software can be adapted to work with a variety of nuclear analysis packages. UNF-ST&DARDS combines SNF assembly data, cask geometries, and analysis tools such as the SCALE code to automatically create and evaluate models of SNF casks. UNF-ST&DARDS predicts the activity of each individual assembly in each individual cask. It then uses this information in shielding analysis, yielding more accurate dose rate predictions compared to those obtained using the traditional bounding analysis.

The realistic dose assessment models in UNF-ST&DARDS, however, must be supported by proper validation to ensure public safety. Validation is necessary to gauge the accuracy of shielding models and the general assumptions used to develop input files. Moreover, validation is necessary to understand the accuracy of underlying analysis codes used to support accurate dose estimation by UNF-ST&DARDS.

The SCALE code package already uses a substantial benchmarking suite. While the computational methods are validated, sometimes using analytical solutions, the actual inputs and assumptions used to create them should be evaluated to gauge accuracy for the intended application. Numerous radiation transport benchmarks are available for code validation as part of the Shielding Integral Benchmark Archive and Database (SINBAD). Unfortunately, the SINBAD database does not contain SNF cask shielding benchmarks.

Additionally, there are only a handful of cask benchmarks published in the open literature. Foremost among these is a 1995 Electric Power Research Institute (EPRI) report listing several benchmark cases with measurements at numerous geometric locations, along with detailed problem specifications [2]. From the same period, work by Jones and Thomas reports dose rates at three locations around a NUHOMS-24P cask [3].

After 1995, a few additional benchmarking cases were developed. These include a TN-12 SNF cask, with dose rates at three locations [4], and work by Asami et al. to model cask lifting points, which represent irregularities in the cask surface [5]. In 2008, the Korea Atomic Energy Research Institute published dose rates at six measurement locations along a KN-12 cask [6]. While a substantial amount of potential benchmarking information is held by utility sites in the form of radiation surveys, and cask manufacturers in the form of proprietary design drawings, this information is unavailable for general use. To evaluate assumptions in the input, a precise, detailed-problem specification is desirable, and first-hand observation of measurements is even better.

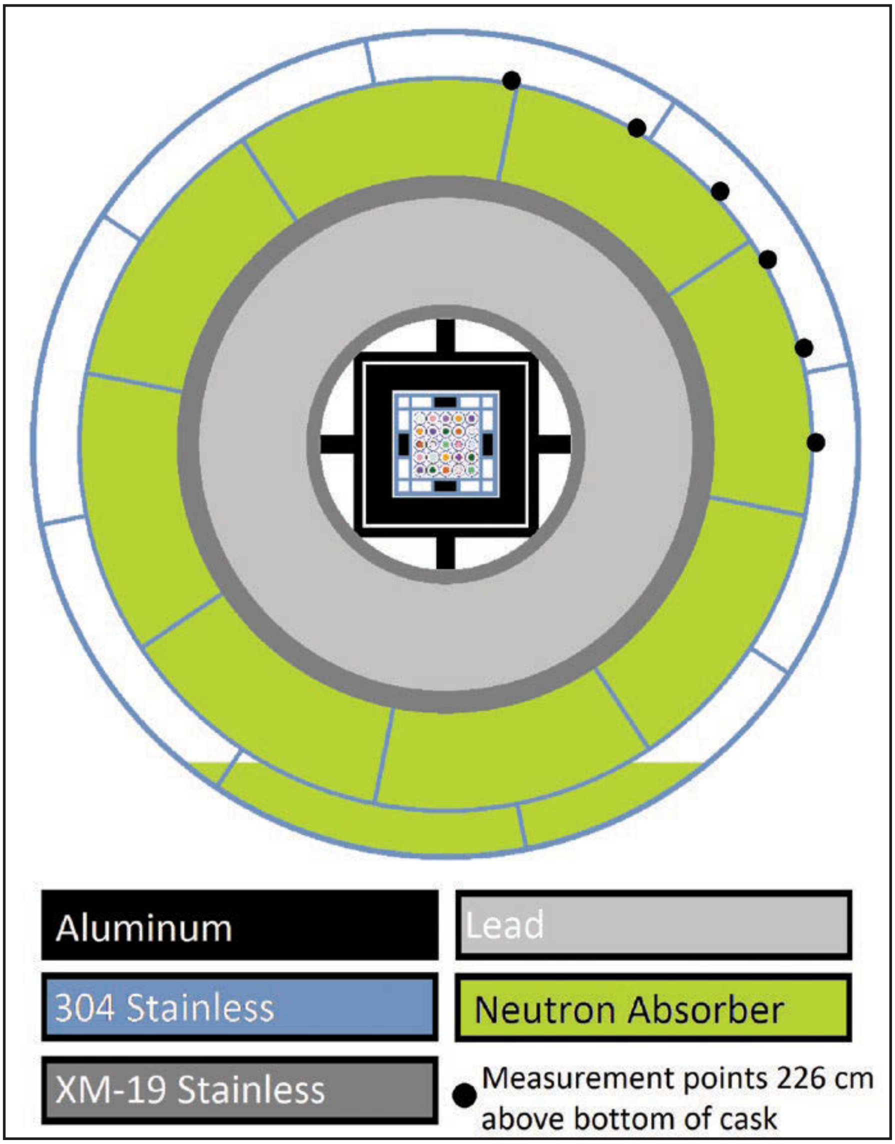


Fig. 1. NAC-LWT radial slice.

NAC-LWT cask

An opportunity to develop additional benchmarking data for SNF casks arose when an NAC International legal-weight truck cask (NAC-LWT) containing 25 high-burnup (>45 GWd/MTU) SNF rods arrived at ORNL in 2016. Shortly after its arrival, gamma dose rates were obtained at various locations along the cask's surface using survey equipment on hand. Subsequently, a shielding model was developed to correspond to the cask geometry and contents and was compared with those measurements.

The 25 rods were part of the High Burnup Spent Fuel Data Project [7] to better characterize phenomena occurring during dry storage of high-burnup SNF, including the extent and implications of hydride reorientation, a phenomenon that can change cladding mechanical properties. To create baseline measurements for the data project, the 25 rods were delivered to ORNL for post-irradiation examination.

A loaded NAC-LWT with impact limiters has a mass of 23.5 metric tons (t) and measures approximately 1.1 meter in diameter and 5.1 m in length. The cask can transport a variety of SNF payloads, including an entire boiling water reactor assembly, a pressurized water reactor assembly, a range of research reactor fuel, and individual fuel rods [8].

As shown in Fig. 1, the side of the cask consists of a lead gamma shield poured into an XM-19 high-strength stainless steel shell and then carefully cooled to avoid the creation of voids. A second layer of shielding consists of a borated ethylene glycol solution for neutron absorption enclosed by a Type 304 stainless steel shell. A second 304 stainless steel shell provides overflow space for the thermal expansion of the neutron absorber fluid [8], while stainless steel plates support the shells containing the fluid. The cask is designed to prevent bubbles from entering the neutron shield area during nonaccident conditions. The neutron emission rate is low enough that any loss during accident conditions typically results in an acceptable dose rate, given the circumstances.

The NAC-LWT received at ORNL was equipped with an aluminum PWR basket that can hold a PWR assembly or a rod canister. In this case, the 25 high-burnup rods were transported in a rod canister. An aluminum PWR insert was used to fill the void between the PWR basket and the rod canister [8].

Benchmarking methods

Measurements

Gamma dose rate measurements were taken primarily on the side cask wall along two axially oriented lines (Fig. 2) and an azimuthally oriented line (Fig. 1) using readily available equipment. The azimuthal line was in a location without the neutron shield overflow tank, as shown in Fig. 1.

The first set of measurements was performed with an Eberline RO-20 ion chamber. The second and third sets included additional measurement locations, and they were performed with a

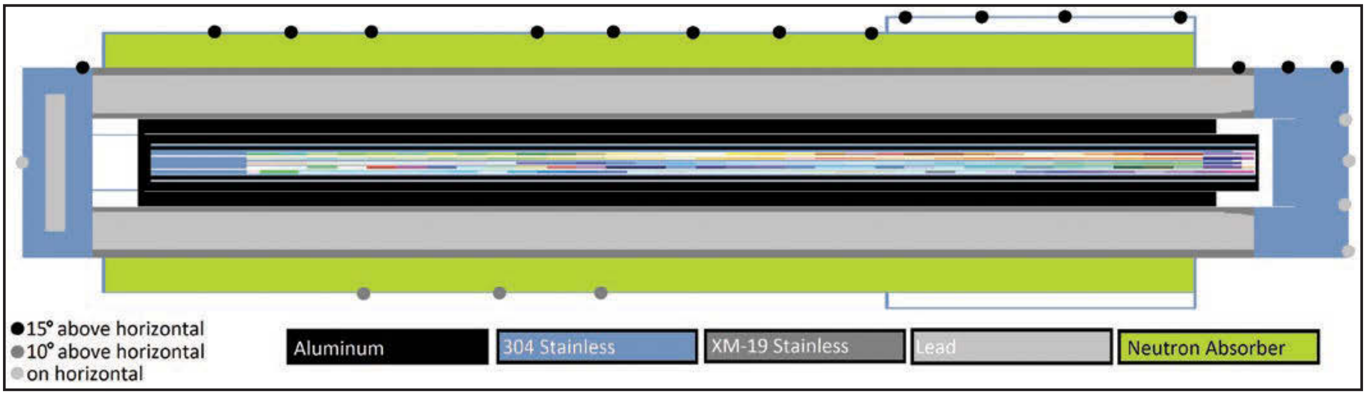


Fig. 2. NAC-LWT axial slice with measurement points.

Radeye B20-ER Geiger counter. For both instruments, dose rates were close to the detection limit. For the Radeye, this meant that the right-hand digits varied with time. Thus, two readings were taken with the Radeye for every measurement location. Unfortunately, neutron dose was not expected to be detectable with the available instrumentation.

Computer codes and model

Shielding analysis was performed using the MAVRIC code, which is part of the SCALE code system [9]. Cask shielding using Monte Carlo methods can be a challenging problem, because the vast majority of particles are absorbed by the cask. If one particle in 1 million survives, a trillion particles must be simulated to obtain a sample of a million particles outside the cask. Modeling casks in any detail can thus become computationally prohibitive.

To address this challenge, SCALE uses the FW-CADIS methodology. FW-CADIS uses approximate forward and adjoint discrete ordinates flux calculations to inform Monte Carlo sampling in the shielding model and thus accelerate solution convergence. The adjoint computation is used to reduce sampling of source particles that contribute almost nothing to the dose rates of interest. For example, photons with an energy in the 1-10 keV range may be a million times less likely to survive through some shield than particles in the 100 keV-1 MeV range, but the low-energy photons are produced 10 times as often by the radiation source.

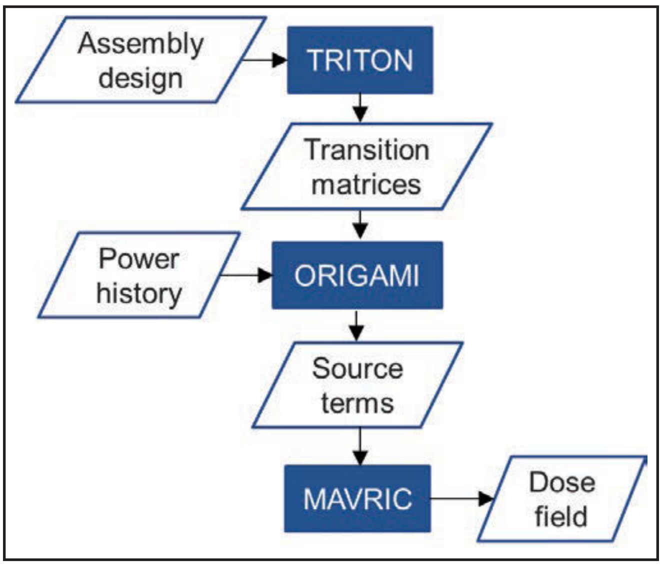


Fig. 3. Computational sequence.

An approximate adjoint flux calculation would show that these particles contribute almost nothing to the dose rate, so they are sampled less often. This would result in a 90 percent reduction in computation time in this example case. The forward computation is used to ensure that every tally region outside the cask has a Monte Carlo uncertainty on the same order of magnitude.

The flux-to-dose conversion factors currently used in the UNF-ST&DARDS shielding models [10] were used to convert the gamma flux at each point to a dose rate. They are the only flux-to-dose conversion factors specifically deemed acceptable in the standard review plans for the storage [11] and transportation [12] of SNF. (ENDF/B-VII.0 continuous energy cross sections were used.)

Radiation sources for the shielding model were computed using TRITON and ORIGEN, with proprietary data regarding pin dimensions and burnup for assemblies. More generic information about the 25 rods is available in the *High Burnup Spent Fuel Data Project Sister Rod Test Plan Overview* [7]. This process is shown in Fig. 3. For a given assembly geometry, TRITON computes the probability that an isotope will be transmuted as a function of time and burnup. ORIGEN combines these probabilities with assembly power history to compute the isotopes present in the SNF and the amounts and types of radiation that the SNF produces. Both tools are part of the SCALE code package.

Radiation sources were computed for 32 axial segments along the active region of each rod, representing assembly-specific axial burnup profiles developed from power maps. The source term for each rod was evaluated using assembly-specific burnup history. Future work will examine the impact of using more approximate data to develop source terms.

Model geometry was based on publicly available licensing drawings [8]. The cask was loaded on a steel frame approximately 1 m above a coated concrete floor. Since measurement points were taken above the horizontal center plane of the cask, the floor and steel frame were not modeled.

Results

The calculated and measured data are presented in Fig. 4. Calculated dose rates typically fall within 0.1 millirem/hour of measured dose rate values. Error bars on calculated values are based on Monte Carlo uncertainty and thus do not reflect all sources of uncertainty. Dose rates were approximately constant along the azimuthal line of measurements taken at 226 centimeters from the left-most edge of the cask, as shown in Fig. 2.

Calculation versus measurement ratios are presented in Fig 5. Fifty-eight percent of the data points fall within 20 percent of the measured results, with the outliers at the top or bottom of the cask. When considering the possible sources of error in geometry specification, materials data, flux-to-dose conversion

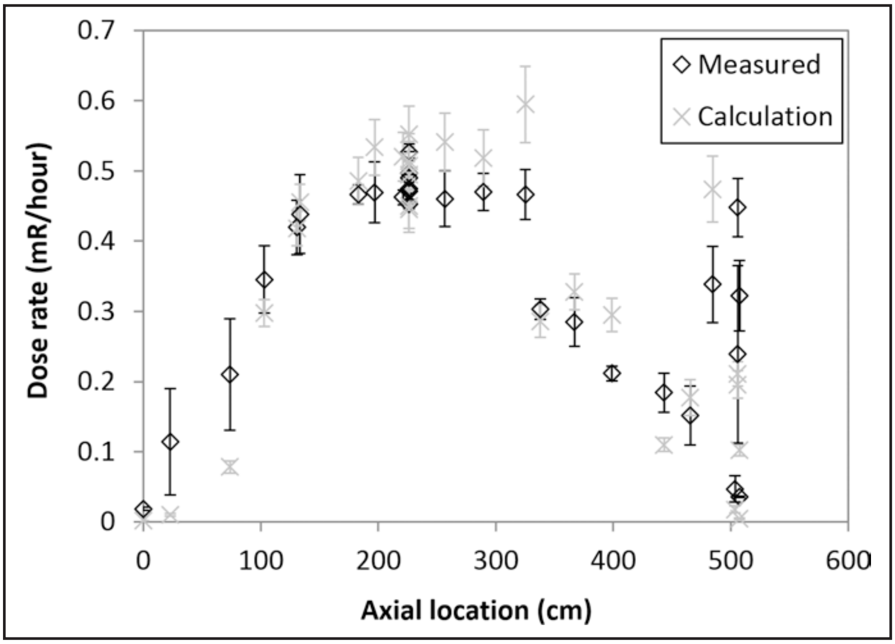


Fig. 4. Measurement vs. calculation; error bars represent one standard deviation; 0 cm is left end of the cask.

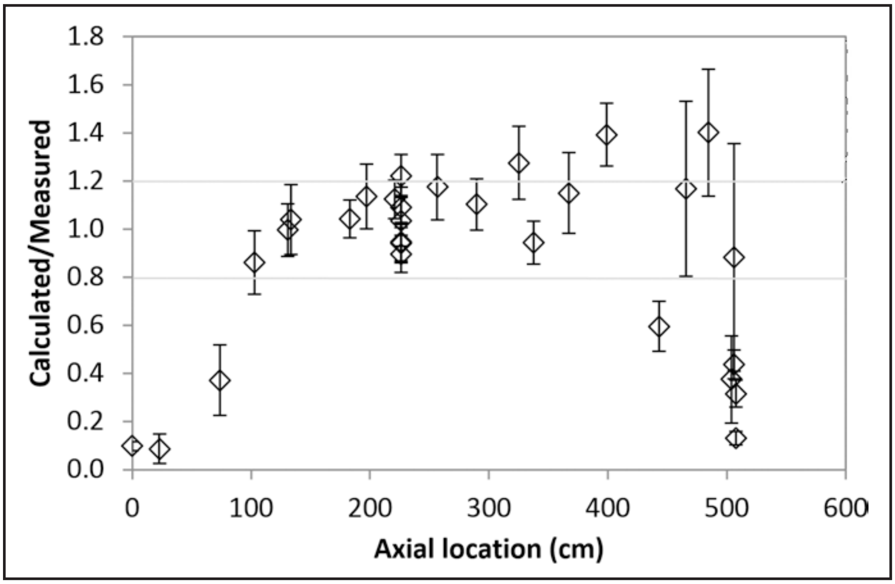


Fig. 5. Calculated to experimentally measured dose rate values with one standard deviation error bars.

function, and source-term calculation, this is generally deemed acceptable.

The cause for the increased discrepancy at the endpoints of the cask is currently unclear. A possibility is under-predicted sources at the extreme ends of the rods. Also, at the endpoints, there is less lead and more iron in the structure, so it could be a material definition issue. In addition, some locations at the top of the cask correspond to bolt recesses, which were not modeled in full detail. Regardless, the correspondence between measured and computed values is quite satisfactory at this juncture.

Dose rates computed with the MAVRIC radiation transport sequence matched measurements, verifying that the SCALE package employed by UNF-ST&DARDS can produce useful results for cask shielding with high-burnup fuel. Additionally, this work provides a basis to examine sensitivities, gauge uncertainty, and examine possible simplifying assumptions. Sensitivity information is expected to prove especially useful to guide the development of shielding models for cask geometries lacking dose rate datasets, focusing attention on quantities that matter most.

Acknowledments

The authors would like to thank Annie Robbins for making the dose rate measurements and Henrik Liljenfeldt for supporting development of source terms for the model.

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Accelerated Corrosion Tests for the Evaluation of Long-Term Performance of Boral in Spent Fuel Pools

By Hatice Akkurt, Ashleigh Quigley, and Matt Harris

Fixed neutron absorber materials are used to increase storage capacity in spent fuel pools (SFP) while maintaining criticality safety margins. Boral is a commonly used neutron absorber material for both wet and dry storage (SFPs and casks, respectively). In the United States, about 50 percent of nuclear power plants use Boral as a neutron absorber material in SFPs [1]. Boral is also used in nuclear plants in Mexico, South Korea, Taiwan, and other countries [1, 2].

Boral is a metal matrix composite containing a mixture of boron carbide (B_4C) and 1100 aluminum alloy [1]. The aluminum cladding, which is on both sides of the core, serves as a protective barrier, as shown in Fig. 1. Al cladding is susceptible to corrosion, which can lead to blisters between the core material and the cladding over time [1, 2]. Based on operational experience to date, pits also have been observed via visual examination and microscopy. Also based on operational experience via coupon test data spanning approximately 30 years, to date no loss of Boral efficacy has been observed [3].

Given that the average nuclear plant lifetime is increasing and subsequently, the SFP lifetime is correspondingly increasing, the Electric Power Research Institute (EPRI) initiated several projects to evaluate the long-term performance of Boral. The first project is a five-year accelerated corrosion test, which was initiated in 2013 to evaluate and determine the long-term performance of Boral in SFPs [4, 5]. Additionally, EPRI initiated the Zion comparative analysis project to 1) determine conditions of the neutron absorber panels, after residing in the SFP of the Zion nuclear power plant for more than 20 years, and 2) evaluate the adequacy of current monitoring approaches, including coupon and in situ measurements. The overall scope of this project allows for the condition of neutron absorber panels to be evaluated and in situ measurements to be compared to actual panel data as well as data obtained from coupon analysis [6-11].

This article presents an overview of the accelerated corrosion

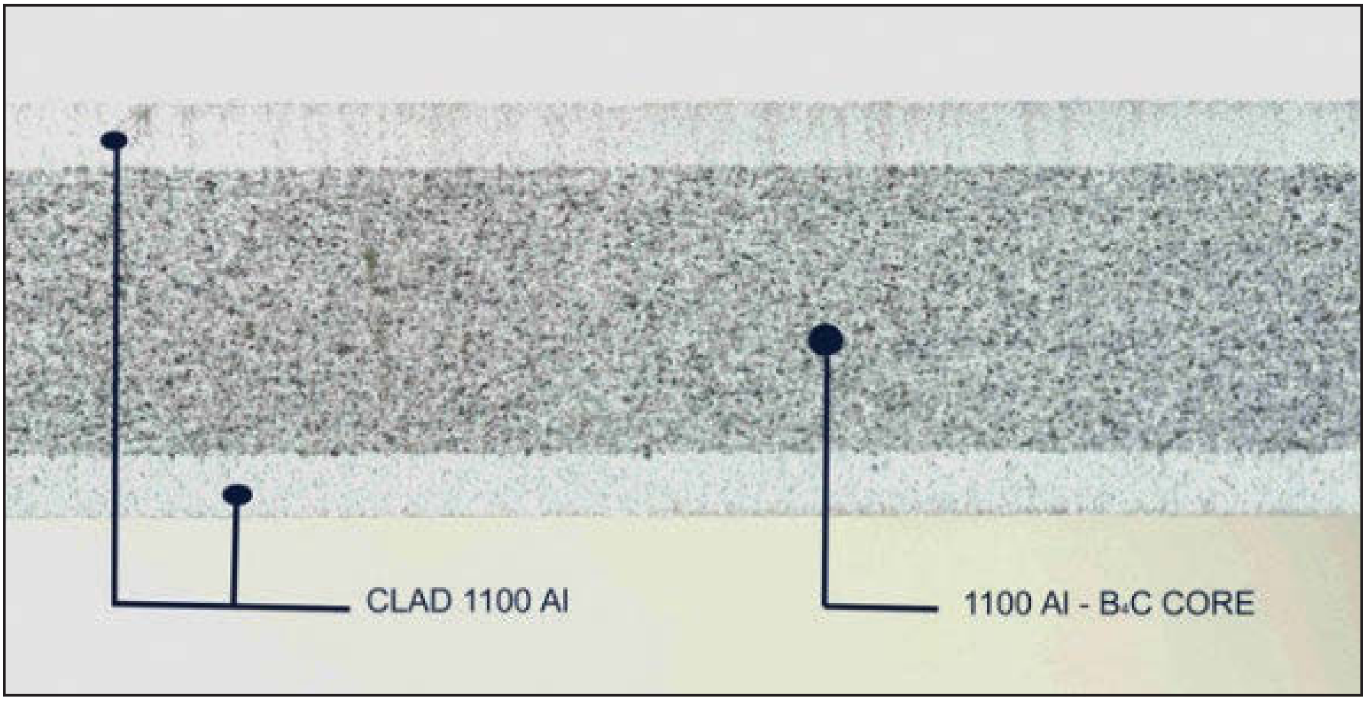

Fig. 1. Microphotograph of Boral.

Fig. 2. Bare (front) and SS-encapsulated (back) Boral coupons in a test bath.

test project. Test results from years one through four of the project are also presented.

Test baths

Over time, there have been changes in the Boral manufacturing process and subsequently, this led to the availability and use of different pedigrees of Boral for storage. As part of this project, different vintages of Boral coupons, with multiple coupons for each type, were collected. A unique identification number for each coupon is etched on the corner of the coupon. To understand and evaluate the differences in behavior, bare coupons with no stainless steel (SS) jacket and SS-encapsulated coupons were placed in test baths. For a few coupons the Al cladding was removed (hereafter referred to as clad-removed) to determine the behavior for the worst-case scenario, as the B_4C core material is directly exposed to water chemistry at elevated temperatures.

These coupons were placed in test baths simulating pressurized water reactor and boiling water reactor water chemistry. The normal operating temperature for SFPs is 80-100° F (27-38° C). The tests are conducted at an elevated temperature of 195° F (91° C) to accelerate the corrosion and determine long-term performance beyond 60 years.

Approximately 100 coupons were placed in each test bath. Prior to placement into the PWR and BWR test baths, each coupon was characterized. The analyses included visual inspection, high-resolution photography, measurement of dimensions and weight of coupons, and most importantly areal density measurements to measure effectiveness for neutron absorption. At the end of each year, coupons representing different pedigrees were removed from both test baths and analyzed. In addition to the pre-insertion characterization, if formed, blister and pit analyses were performed after removal from the test bath. The remaining coupons were left untouched and carried forward to the next year of the study. It should be noted that the Al clad-removed coupons were reinserted into the test baths for future analyses. The bare and encapsulated coupons in one of the test baths are shown in Fig. 2.

The water chemistry was monitored at regular intervals and maintained according to EPRI water chemistry guidelines for PWR and BWR SFPs. As part of the water chemistry, the pH, conductivity, sulfate, chloride, fluoride, and aluminum levels for both PWR and BWR test baths, and boron levels (for PWR bath), were measured and maintained according to the guidelines. However, during Year No. 1, due to issues with the water purification system, the sulfate levels for the PWR test bath were significantly higher than the recommended levels. EPRI water chemistry guidelines recommend keeping sulfate levels below 150 parts per billion. During the first year, however, sulfate levels for PWR test baths were up to 1,500 ppb. The issue was addressed and starting from Year No. 2, sulfate levels returned to the recommended levels.

Areal density for each coupon was measured at the Breazeale Nuclear Reactor at Pennsylvania State University prior to placement into the test baths and after removal for comparison purposes.

Results

Here the areal density results are primarily presented, as they are the most important parameter for performing the intended safety function as a neutron absorber material in SFPs to

Areal density values for bare and encapsulated coupons

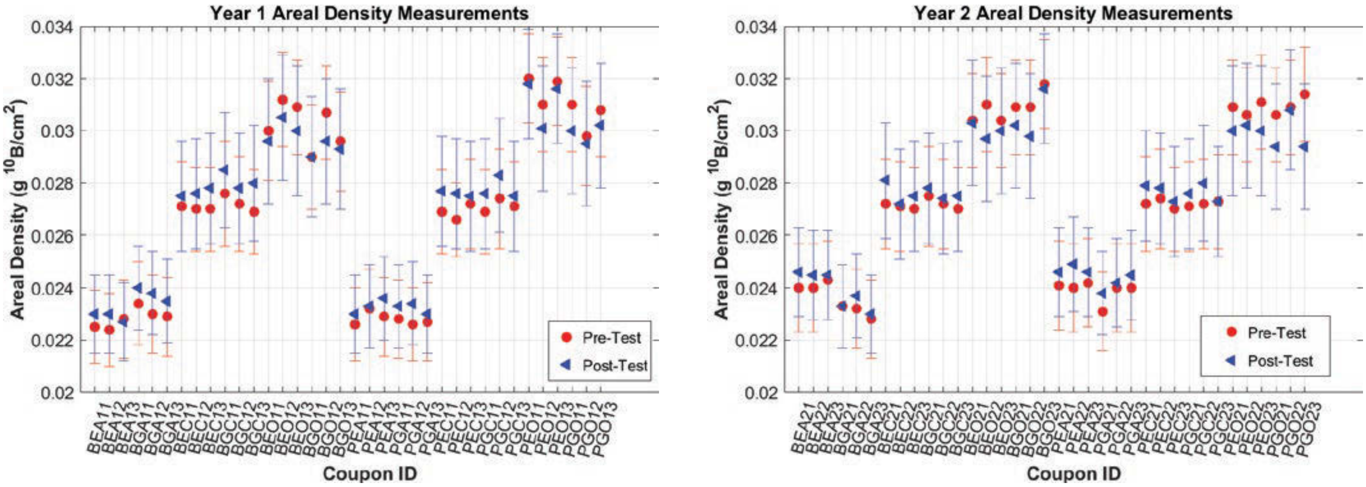

Fig. 3. Areal density values ordered according to coupon label for Year No. 1 (left) and Year No. 2 (right) coupons.

Areal density values for Al clad-removed coupons

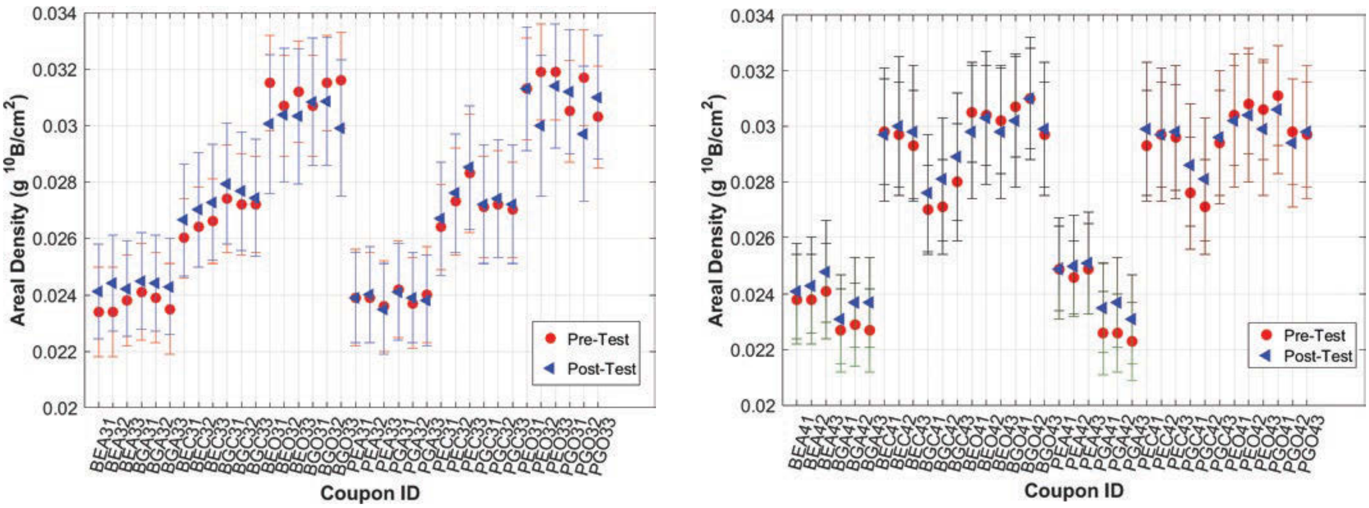

Fig. 4. Areal density values ordered according to coupon label for Year No. 3 (left) and Year No. 4 (right) coupons.

maintain criticality safety margins.

Fig. 3 shows the areal density values as characterized prior to placement in the test baths and after immersion in test baths for Year No. 1 (left) and Year No. 2 (right) coupons. The areal density values as characterized prior to placement in the test baths and after immersion in test baths for Year No. 3 (left) and Year No. 4 (right) coupons are shown in Fig. 4. In these figures, the coupons are ordered according to coupon identification numbers. In these figures, error bars show 3σ values.

The key for coupon labeling is:

- P (PWR); B (BWR);
- E (Encapsulated in SS jacket); G (General, bare with no SS jacket);
- A (manufacturer A); C (manufacturer C); O (manufacturer O);
- The first number indicates the designated year of the coupon analysis;
- For each year, three coupons of each type were immersed in test baths to identify if there are variations in degradation within the same type when exposed to the same conditions for the same amount of time. Subsequently, the last number indicates the coupon number within that batch.

As can be seen from Figs. 3 and 4, there is no statistically significant change in the areal density values for any of the coupons following immersion in test baths at elevated temperatures for Year Nos. 1-4. The changes in areal density values are within 3σ values, compared with precharacterized values. The results to date are encouraging for demonstrating the long-term performance of Boral, as areal density is the most important parameter for any neutron absorber in order to determine performance of its intended function and maintenance of criticality safety margins.

For some of the coupons, the Al cladding surrounding the Boral was removed mechanically before the coupons were placed into the test baths. These coupons represent the worst-case scenario, as they do not have the protective Al clad. Since there were a limited number of these clad-removed coupons, they were reinserted into the test baths following the Year No. 2 analysis. The clad-removed coupon prior to placement in the test bath (left), after immersion in the test bath for two years (center), and after immersion in the test bath for four years (right) is shown in Fig. 5.

The areal density values for clad-removed coupons, prior to placement in the test bath and after being in the test bath for two and four years, are shown in Fig. 6. As evident from the figure, none of the clad-removed coupons show any statistically significant change in areal density values, even after Year No. 4. These are very substantial results, as they demonstrate that even for the worst-case scenario (when Al clad is removed), there is still no loss of Boral.

It is also important to emphasize that despite the fact that Year No. 1 sulfate levels were significantly higher than recommended values for PWR coupons, there is no significant change in areal density. This is especially important for clad-removed coupons,

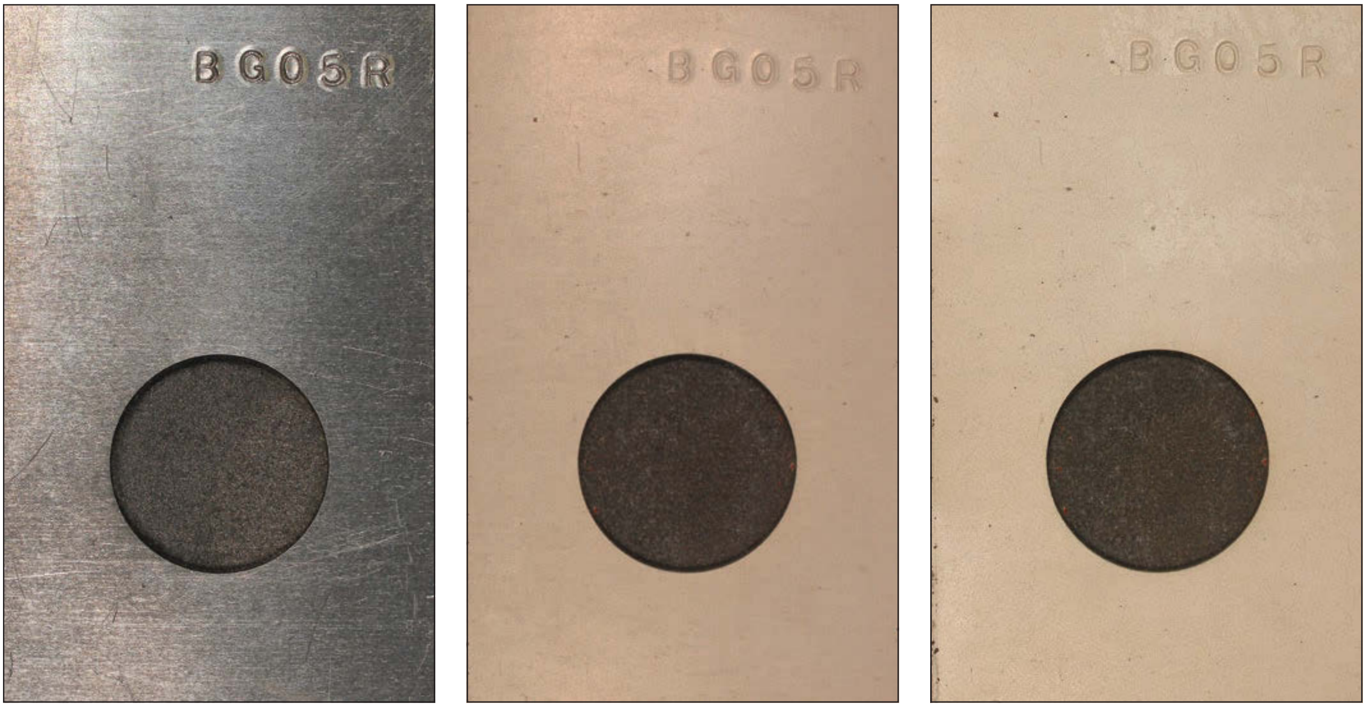

Fig. 5. Clad-removed coupon prior to the placement in a test bath (left) and the same coupon after immersion in a test bath for two years (center) and four years (right).

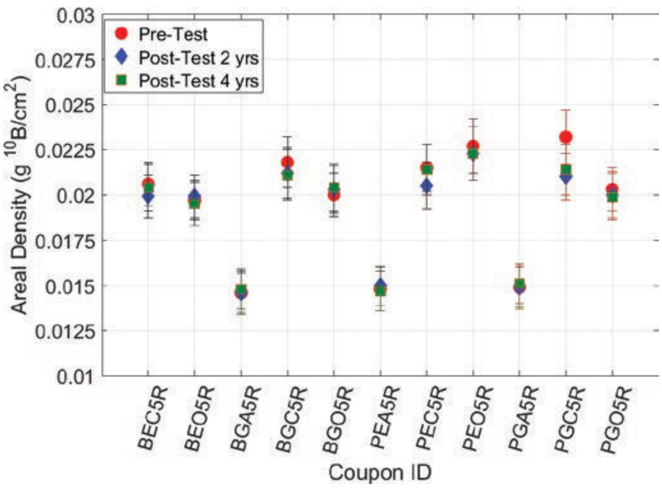

Fig. 6. Areal density values for clad-removed coupons after immersion in PWR and BWR test baths after two and four years.

as sulfate is a known corrosion accelerator.

The tests on this set of coupons are still in progress and are planned to conclude at the end of Year No. 5 in 2018. At the conclusion of the tests, results will be published in an EPRI report.

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The on-site EMWMF waste facility is an above-grade waste disposal facility that is authorized to receive low-level radioactive and other regulated wastes from cleanup work associated with the Oak Ridge Reservation. (Photos courtesy of UCOR)

The Waste Factory Approach

Meeting the formidable waste management challenges at Oak Ridge's East Tennessee Technology Park using on-site resources.

By John Wrapp

Over its 75-year life, the 2,200-acre East Tennessee Technology Park (ETTP) in Oak Ridge, Tenn., has seen unprecedented transformations—from weapons production facility to environmental cleanup site to multiuse industrial park.

In 1942, the rolling hills of east Tennessee became part of the most significant defense initiative in the history of the United States—the Manhattan Project. Within 18 months, a 44-acre concrete and steel facility, known as K-25, replaced the rural landscape. The plant would enrich uranium using the gaseous diffusion process.

Ultimately, K-25's product would fuel one of two atomic bombs that would end World War II. Over the next decade, another four uranium enrichment facilities joined K-25. For more than 40 years, the site evolved and adapted to meet the nation's changing defense and energy needs.

In 1985, uranium enrichment activities ceased at the site and a new mission emerged. The Department of Energy, the site's owner and operator, turned its focus to the cleanup of the environmental legacies created by Oak Ridge's industrial processes. By the mid-1990s, a comprehensive cleanup strategy was in place, and the DOE announced its long-term vision for the site as a private-sector industrial park. Through a process known as reindustrialization, infrastructure and restored lands and buildings were transferred to private entities for redevelopment and reuse.

Now, in the final chapter of one of the nation's largest environmental cleanup projects, all five enrichment buildings have been demolished. Crews have begun work to remove the site's remaining structures and restore contaminated land. Their work will include closure activities that fulfill the DOE's cleanup obligations and completing the transfer of lands and properties for redevelopment and reuse.

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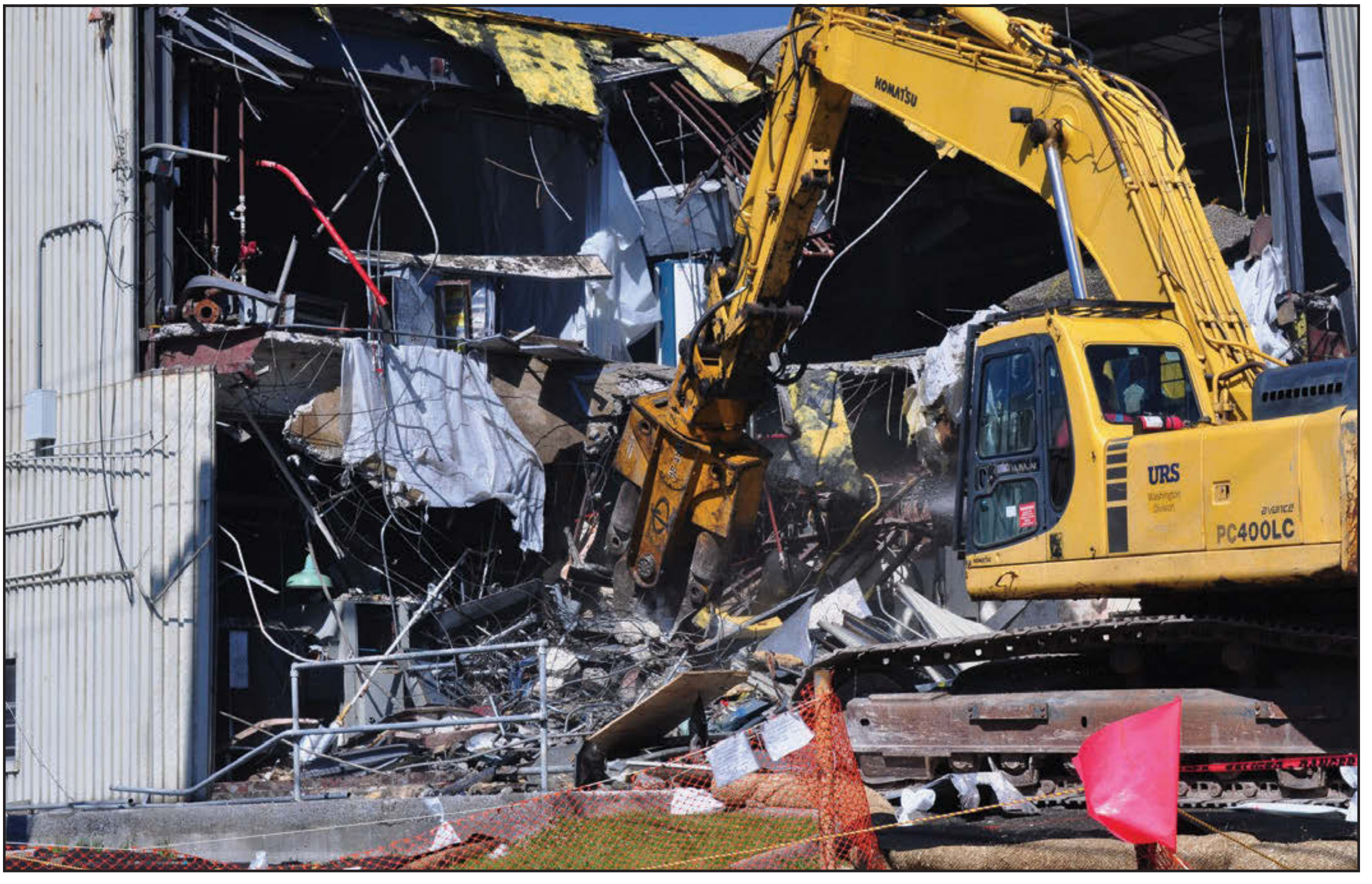
A truck is loaded with demolition debris for transfer to Oak Ridge's EMWMF.



An inoperative Oak Ridge building is torn down. Since August 2011, the DOE and UCOR have completed 67,850 shipments containing 784,878 y^3 of waste without injury or release to the environment.

Cleanup challenges

As a former uranium enrichment plant site, the ETTP presents many formidable cleanup challenges. Buildings planned for demolition are laced with radioactive materials and years of unregulated waste disposal practices have polluted the soil and groundwater. The extent of contamination was not fully known, and the unsafe, deteriorated condition of many of the structures forced many delays in demolition.

Demolition of the site's centerpiece—the K-25 gaseous diffusion plant—was the largest teardown ever undertaken within the DOE complex. The building enclosed some 2 million square feet of space—44 acres under one roof—making it the largest building in the world at the time. Because it was contaminated with radioactive materials and was in a deteriorated state, its demolition was a high priority for the DOE.

Four other massive gaseous diffusion facilities known as K-27, K-29, K-31, and K-33 were also demolished as part of the site cleanup.

The waste factory

When DOE contractor URS CH2M Oak Ridge (UCOR) began its role to support the department's unprecedented environmental cleanup at ETTP, it was continually challenged regarding how to handle tons of debris and discarded equipment that was once part of this historic national security complex. A large part of the answer, and a key factor in the success of the cleanup, lay in an innovative "waste factory" approach that offered streamlined waste handling, transportation, and permanent on-site disposal.

In disposing of low-level radioactive and other wastes from demolition activities, the approach relied on the availability of on-site facilities to streamline disposal, reduce costs, and enhance cleanup schedules while confining shipments and attendant hazards on-site.

The waste factory approach has demonstrated exceptional value and benefits and has proven worthy of consideration as a model for waste management operations across the DOE complex and in other industries where significant quantities of waste must be disposed of. Without the availability of dedicated haul roads and secure disposal on-site, the DOE would have been forced to send hundreds of millions of pounds of waste by truck to repositories across the country, increasing costs and slowing cleanup.

As an example, assuming that a typical road shipment to an off-site facility could range from 25 to 75 cubic yards, the number of shipments through the surrounding counties and communities across the country could range from 1,200 to 3,700 per year. This equates to six to 18 shipments per day. The substantial cost required for cross-country transportation would have resulted in fewer cleanup activities in Oak Ridge and added years to the cleanup schedule.

On-site disposal also greatly enhances safety. Since August 2011, the DOE and UCOR have completed 67,850 shipments containing 784,878 y^3 of waste, traveling 4.5 million miles without injury or release to the environment.

Strict waste acceptance criteria governed the type of wastes that were disposed of on-site. For the most part, the wastes comprise soil, sludge sediments, solidified waste forms, stabilized waste, vegetation, building debris, personal protection equipment, and scrap equipment.

Inevitably, some waste that does not meet the on-site waste acceptance criteria must be shipped to other locations for disposal,

A sodium shield at Oak Ridge's ETTP awaits disposition.

but it is a small amount. Approximately 95 percent of the volume of cleanup waste on the Oak Ridge Reservation is stored on-site, while only about 5 percent has been disposed of off-site. At the same time, only about 15 percent of the radioactive curie content has been disposed of on-site, while 85 percent is being disposed of off-site.

Work scope

When UCOR assumed responsibility for the cleanup of ETTP in 2011, one of the first tasks was to survey the site to discover any outstanding issues and hazards that might not have been identified in the initial scope of work. Any major issues that were uncovered as part of this standard due diligence exercise are termed "material differences" and are addressed with a contract modification. With the DOE agreement, additional work scope is added to the base contract along with the funding necessary to complete the tasks.

One set of material differences identified in the early days of UCOR's contract with the DOE involved assorted legacy waste items scattered across the site but not captured as part of the contract's cleanup scope. The waste ranged from clean surplus steel ready for recycle to abandoned waste tanks, hazardous chemicals, and radioactive-contaminated equipment.

After negotiating a contract modification, UCOR went to work cleaning up the waste, a task that has just been completed as the DOE work agreement enters its sixth year. Most of the waste was not associated with specific projects but were random equipment and materials considered stray hazards that still constituted a threat to the environment, as well as the health and safety of employees and the public.

Cleaning up legacy waste poses special challenges that are not encountered in a pack-as-you-go approach to managing new waste and debris that are generated in the demolition process. If waste is not disposed of at the time it is generated, the cost and complexity is much higher and more difficult.

One primary reason is that it is often difficult to know exactly what is in old waste containers that have been stored for years. It takes time to examine the containers and determine what is inside. The possibility of exposure to workers is much higher because of the unknown. It is a meticulous process that requires a container-by-container inspection and characterization. The overall cost associated with characterizing legacy waste is generally much higher because of the unknown nature of the waste and, in most cases, has to be done on an individual basis versus a waste-stream basis.

Once the waste was characterized, it was prepared for disposal either on-site in the Environmental Management Waste

Management Facility (EMWMF) or the Oak Ridge Reservation sanitary landfill. Some waste was shipped to the Nevada National Security Site for disposal.

Waste streams

On another front, the DOE seeks the safest, most environmentally protective and fiscally responsible treatment for its large inventory of radioactive-contaminated metals known as “shields.” Sixty-six sodium and lithium shields were constructed for use in experiments at the Tower Shielding Facility (TSF) at Oak Ridge National Laboratory. The TSF operated from 1954 to 1992 and was designed and built for radiation-shielding studies.

The shield containers are constructed of aluminum or stainless steel of varying sizes and shapes that were then filled with either sodium metal or lithium hydride material. The sodium and lithium shields were initially used at the TSF to perform in-depth measurements of the neutron transport through the shield materials. Based on process knowledge, the shields are managed as radiologically contaminated containers. Efforts have been made over the last 15 years to find recycle markets for both the sodium and lithium hydride shields. This includes an on-site operation that was initiated at ETTP in 2004.

The amount of time needed to reasonably identify safe disposition or recycling outlets for the shields was expected to exceed the DOE’s one-year land disposal restrictions storage time limit; therefore, approval was received to add the shields to Oak Ridge’s site treatment plan in March 2017.

Until a disposition path is determined, the shields will continue to be stored in a safe configuration that protects human health and the environment. This engineering evaluation identifies and screens the alternatives for dispositioning the shields at the Oak Ridge Reservation. Four alternatives were evaluated, including: 1) macroencapsulation, 2) deactivation, 3) recycle, and 4) leave-in-place. An initial screening was performed and the alternatives passing the initial screening were then evaluated in more detail. The evaluation criteria that were used included environmental risk, technical feasibility, administrative feasibility, worker safety, nuclear safety, transportation safety, and cost. To date, no alternative has been accepted, but studies continue.

When UCOR inherited the cleanup contract at ETTP, there was an inventory of seven waste streams that were identified as having no path to disposal. This meant that the previous contractors could not find a compliant disposition method for treatment/disposal of these seven waste streams. After an extensive effort to evaluate the characterization and treatment options for these waste streams, UCOR has dispositioned the inventory of 6.5 of the seven original streams. The only portion that remains is a liquid-phase dioxin/furan waste stream. UCOR is working with the Environmental Protection Agency on a treatment variance to open a path for the disposition of this final partial waste stream. ■

John Wrapp is the waste disposition manager for UCOR at Oak Ridge, Tenn.

For disposing of GTCC and GTCC-like low-level radioactive waste, the DOE is primarily considering disposal at generic commercial facilities. Waste Control Specialists operates the Federal Waste Facility in Texas. (Photo: WCS)

DOE Report to Congress on GTCC Waste Disposal Alternatives

On Nov. 14, 2017, the Department of Energy submitted a report to Congress titled, Alternatives for the Disposal of Greater-than-Class C Low-Level Radioactive Waste and Greater-than-Class C-Like Waste.

The report satisfies a statutory requirement in the Energy Policy Act of 2005, which requires that prior to making a final decision on the disposal of GTCC waste, the Secretary of Energy submit a report to Congress describing the alternatives under consideration and await action by Congress.

The following excerpt from that report has been edited for clarity and length.

In February 2016, the Department of Energy issued the *Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (DOE/EIS-0375) (Final EIS). This document evaluates the potential environmental impacts associated with the proposed development, operation, and long-term management of a disposal facility or facilities for GTCC low-level radioactive waste (LLRW) and GTCC-like waste in the DOE's inventory as shown in the Final EIS.

GTCC LLRW has radionuclide concentrations exceeding the limits for Class C LLRW established by the U.S. Nuclear Regulatory Commission. GTCC LLRW is generated by NRC or Agreement State (i.e., a state that has signed an agreement with the NRC to regulate certain uses of radioactive materials within the state) licensees. Federal laws specify that the federal government is responsible for the disposal of GTCC LLRW.

At this time, there is no disposal facility for GTCC LLRW. GTCC-like waste is radioactive waste that is owned or generated by the DOE (including LLRW and nondefense-generated transuranic (TRU) waste), has no identified path to disposal, and has characteristics similar to those of GTCC LLRW, suggesting that a common disposal approach may be appropriate.

Waste inventory

The total estimated volume of GTCC LLRW and GTCC-like waste that was in storage as of 2008 and projected (anticipated through 2083) is approximately 12,000 cubic meters, or 420,000 cubic feet, and contains about 160 million curies (MCi) of radioactivity. About 75 percent of the total inventory in the Final EIS is made up of GTCC LLRW, with the remaining amount is made up of GTCC-like waste.

GTCC LLRW and GTCC-like waste can be grouped into three waste types: activated metals, which have been largely generated from the decommissioning of commercial nuclear utilities; sealed sources; and other wastes that include contaminated equipment, debris, scrap metal, filters, resins, soil, and solidified sludges. For analysis in the Final EIS, the three waste types are divided into two groups on the basis of uncertainties associated with their generation.

Group 1 consists of wastes that are either already in storage or are expected to be generated from operating facilities (such as commercial nuclear power plants). All currently operational plants were assumed to have their license renewed for an additional 20 years of operation. All stored GTCC LLRW and GTCC-like wastes are included in Group 1. Of the 12,000 m^3 total inventory in the Final EIS, the waste volume in Group 1 is estimated to be 5,300 m^3 (190,000 ft^3) and this waste contains a total of 110 MCi of activity. The radionuclide activity is mainly from the decommissioning of commercial nuclear power reactors currently in operation.

Group 2 consists of projected wastes from proposed actions or planned facilities not yet in operation. These actions include those proposed by the DOE and those to be conducted by commercial entities (including electric utilities) for an assumed number of new (i.e., still to be licensed or constructed) nuclear power plants. Some or all of the Group 2 waste may never be generated, depending on the outcome of the proposed actions that are independent of the Final EIS. No stored GTCC LLRW and GTCC-like wastes are included in Group 2. Of the 12,000 m^3 total Final EIS inventory, Group 2 has an estimated waste volume of 6,400 m^3 (230,000 ft^3) and contains a total activity of 49 MCi. The radionuclide activity in the Group 2 wastes would result mainly from the decommissioning of proposed new commercial nuclear power reactors.

Disposal alternatives

In the Final EIS, the DOE evaluated a range of disposal methods and locations for disposal of GTCC LLRW and GTCC-like waste. The disposal methods evaluated vary in depth of disposal and include: intermediate-depth boreholes, enhanced near-surface trenches, above-grade vaults, and a geologic repository.

The Final EIS evaluated generic commercial disposal sites on the basis of a regional approach that divides the United States into four regions consistent with the NRC's designations of Regions I through IV. Region I includes the 11 states in the Northeast; Region II includes the nine states in the Southeast; Region III comprises the eight states in the Midwest; and Region IV comprises the remaining 22 states in the West. Generic commercial sites were evaluated because they are considered a reasonable alternative to dispose of GTCC LLRW and GTCC-like waste.

DOE disposal sites that were evaluated include:

- Hanford Site, Washington;
- Idaho National Laboratory, Idaho;
- Los Alamos National Laboratory, New Mexico;
- Nevada National Security Site, Nevada;
- Savannah River Site, South Carolina;
- Waste Isolation Pilot Plant (WIPP), New Mexico; and
- WIPP vicinity in New Mexico (WIPP vicinity refers to two sections: Section 27, which is within the WIPP Land Withdrawal Boundary and administered by the DOE, and Section 35, which is just outside the WIPP Land Withdrawal Boundary to the southeast and administered by the Bureau of Land Management in the U.S. Department of the Interior).

Among the DOE sites, only WIPP was included in the preferred alternative.

The Final EIS evaluated five alternatives: 1) no action (continue current practices for storing and managing GTCC LLRW in accordance with NRC requirements and GTCC-like waste in accordance with DOE and state requirements), 2) disposal in a new intermediate-depth borehole facility, 3) disposal in a new enhanced near-surface trench facility, 4) disposal in a new above-grade vault disposal facility, and 5) disposal at the WIPP geologic repository.

It should be noted that TRU waste disposal operations at WIPP were suspended on Feb. 5, 2014, following a fire involving an underground vehicle. Nine days later, on Feb. 14, an unrelated radiological event occurred underground at WIPP, contaminating a portion of the mine primarily along the ventilation path from the location of the incident and releasing a small amount of contamination into the environment. The DOE resumed safe waste emplacement operations at WIPP on Jan. 4, 2017.

Preferred alternative

In developing the preferred alternative for the disposal of GTCC LLRW and GTCC-like wastes in the Final EIS, the DOE considered public comments on the *Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (DOE/EIS-037S-D), human health risks, transportation, cultural resources, and tribal concerns. In addition, the DOE considered security concerns and the projected timing of waste generation.

Given the diverse characteristics (e.g., different radionuclide inventories, range of physical conditions, and derived from both commercial and DOE sources) of GTCC LLRW and GTCC-like waste analyzed in the Final EIS, the preferred alternative selected is not limited to one disposal method. The preferred alternative for the disposal of GTCC LLRW and GTCC-like waste in the Final EIS is land disposal at generic commercial facilities

Table 1: Costs of GTCC LLRW and GTCC-Like Waste Disposal Alternatives[a]

Disposal Method	Cost to Construct the Facility (in millions of $)[b]	Cost to Operate the Facility (in millions of $)[c]	Total Cost (in millions of$)	Total Cost per m^3 ($)	Total Cost per ft^3 ($)
Intermediate-Depth Borehole	250	140	400	33,330	940
Enhanced Near-Surface Trench	110	190	300	25,000	710
Above -Grade Vault	430	190	620	51,670	1,460
WIPP Geologic Repository[d]	17	670	690	57,500	1,630

[a] The costs provided are in 2016 dollars, which have been escalated from the estimates in the Final EIS which were in 2008 dollars . Some totals may not equal the sum of individual components because of independent rounding .

[b] Construction costs for the borehole, trench, and vault disposal facilities are for 930 boreholes, 29 trenches, and 12 vaults (consisting of 130 total vault cells), respectively, and the supporting infrastructure. Construction costs for the WIPP facility are for 26 new rooms.

[c] Operational costs assume 20 years of facility operations for the borehole, trench, and vault disposal methods . On the basis of the assumed receipt rates, the majority of the wastes would be available for emplacement during the first 15 years of operations .

[d] WIPP repository cost estimate in the Final EIS includes operating costs incurred for ongoing non-GTCC disposal operations. (Source: DOE)

and/or the WIPP geologic repository.

Full waste emplacement operations at WIPP are not expected until the 2021 time frame, and therefore the DOE is primarily considering disposal at generic commercial facilities. The preferred alternative does not include disposal at any DOE sites other than WIPP. In addition, there is currently no preference among the three land disposal methods that would be implemented at generic commercial sites.

The analysis in the Final EIS has provided the DOE with the information needed to identify a preferred alternative with the potential to enable the disposal of the entire waste inventory analyzed in the Final EIS. The DOE has determined that the preferred alternative would satisfy the needs of the department for the disposal of GTCC LLRW and GTCC-like waste.

The preferred alternative identified in the Final EIS does not constitute a decision by the DOE. In accordance with the Energy Policy Act of 2005, the DOE must await action by Congress before making a decision on which alternative or alternatives to implement.

Cost estimates

The cost estimates provided in the Final EIS are conceptual in nature; hence the accuracy range, in accordance with DOE Guide 413.3-21 (change 1), *Cost Estimating Guide,* is expected to be -20 percent to +50 percent. As noted in the Final EIS, the total estimated costs (facility construction and operation) for disposal of GTCC LLRW and GTCC-like waste at an intermediate-depth borehole facility, enhanced near-surface trench facility, or above-grade vault facility ranged from $300 million to $620 million in 2016 dollars (Table 1). For the WIPP geologic repository, the estimated cost for GTCC LLRW and GTCC-like waste disposal would be approximately $690 million. The cost to operate the WIPP geologic repository is higher than other alternatives because, in general, staffing/labor, waste handling, safety, equipment, infrastructure, maintenance, utilities, oversight, and regulatory requirements for a geologic repository are far more complex than for near-surface land disposal options.

All costs are based on the total Final EIS inventory volume of 12,000 m^3. These cost estimates do not include waste facility permits, licenses, packaging, transportation, and post-closure activities. Once a final decision is made on the disposal alternative, a site-specific estimate of total costs related to disposal of GTCC LLRW and GTCC-like waste will be developed.

The actual start date for operations is uncertain at this time and will depend upon the alternative or alternatives selected, the preparation of additional National Environmental Policy Act analyses, if necessary, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility.

Disposal fee options

Section 3 (b)(3)(E) of the Low Level Radioactive Waste Policy Amendments Act of 1985 requires the DOE to identify "options for ensuring that the beneficiaries of the activities resulting in the generation of such radioactive wastes bear all reasonable costs of disposing of such wastes."

In a comprehensive 1987 GTCC report to Congress, the DOE identified two funding options that could be established to allocate costs of waste disposal to the generators. Both funding mechanisms are based upon estimates of waste volumes, types, and costs associated with each waste type. Legislation would be required for either of these funding options to be implemented. The funding options include:

Advanced Fee Assessment and Collection Upon Waste Generation Option: This fee, similar to that for the Nuclear Waste Fund under the Nuclear Waste Policy Act (NWPA), could be established to collect fees to cover the total costs of disposal of some GTCC LLRW. Under this funding option, generators would be required to pay into the fund when the waste is generated.

Under the NWPA, funds for the disposal of spent nuclear fuel from commercial power reactors are collected through the assessment of a fee on electricity generated and sold by a civilian nuclear power reactor as payment in exchange for the federal government's contractual commitment to dispose of spent nuclear fuel and high-level waste. From April 7, 1983, to May 16, 2014, consumers of electricity produced at nuclear power plants paid a fee into the fund of one-tenth of one cent for every kilowatt-hour of electricity generated based on the annual Secretarial Determination of the Adequacy of the Nuclear Waste Fund Fee.

Charge Upon Waste Receipt Option: A fee could be assessed to the generator at the time the waste is delivered for disposal. This approach is similar to that used at commercial disposal sites for Class A, B, and C LLRW. The generator would cover the costs for characterization, packaging, transportation, and disposal. The DOE recommends this option because it is based on the relatively greater certainty in determining costs and charges for specific waste streams.

For example, it is anticipated that fees for disposal of GTCC LLRW at a commercial disposal site would be based on methodology similar to that used at current commercial LLRW disposal sites. Such fees are based upon a core charge, based on the volume of radioactive waste to be disposed of, plus applicable surcharges.

Core charges would be based on a volume fee per cubic meter or cubic foot of the total containerized volume of radioactive waste including: the cost to remove radioactive waste from the storage site and ship to a disposal facility; the cost to return the empty cask from the disposal facility to the storage site for each shipment; the cost to receive, secure, unload, inspect, and decontaminate (if necessary) each shipment; and the cost to dispose of radioactive waste. Surcharges could include an activity charge per curie and a graduated high-dose rate charge per container.

Conclusion

Implementation of the DOE's preferred alternative would result in the cost-effective, safe, and secure disposal of GTCC LLRW and GTCC-like waste inventory outlined in the Final EIS. The preferred alternative is land disposal at generic commercial facilities and/or disposal at the WIPP geologic repository. Full waste emplacement operations at WIPP are not expected until the 2021 time frame, and therefore the department is primarily considering disposal in generic commercial sites. Congressional action is required before the DOE can make a final decision and issue a record of decision on the disposal of GTCC LLRW and GTCC-like waste. The DOE will work with Congress to determine the best path forward for disposal of GTCC LLRW and GTCC-like waste. ■

A SNF overpack is moved onto an ISFSI pad. While a national repository has been delayed, the DOE continues to plan for the eventual removal of spent fuel from U.S. power plants. (Photo: NAC International)

Getting Rid of Inventory

Studies on moving spent nuclear fuel from several closed nuclear power plants have been prepared for the DOE by Orano's federal services team.

By Tim Gregoire

In the United States, there are currently 73 nuclear power sites with independent spent fuel storage installations (ISFSI) licensed by the Nuclear Regulatory Commission, including Fort St. Vrain and Three Mile Island-2. Seven of those power plants have been fully decommissioned, in some cases leaving only the ISFSI remaining on the site. Along with Connecticut Yankee and Maine Yankee, this includes Big Rock Point in Michigan, Fort St. Vrain in Colorado, Rancho Seco in California, Trojan in Oregon, and Yankee Rowe in Massachusetts. Three additional nuclear power plants are set to complete decommissioning in the next few years, including Humboldt Bay in California (2018), La Crosse in Wisconsin (2019), and Zion in Illinois (2020).

With the nation's program for managing spent nuclear fuel (SNF) and high-level radioactive waste currently stalled, the Department of Energy has been laying the groundwork for implementing an integrated waste management system to allow it to take possession of SNF from commercial power reactors as required by law. As part of this initiative, the DOE is planning the transportation infrastructure for the eventual large-scale shipments of SNF and greater-than-Class C (GTCC) radioactive waste to storage and disposal sites. The DOE is looking to ship SNF and GTCC waste primarily by rail, but also by road or barge when a railway is not accessible.

To assist with the planning for the eventual removal of SNF and GTCC waste from reactor sites, Orano (formerly Areva Federal Services) developed a number of reports for the DOE assessing the tasks, equipment, and interfaces necessary to remove SNF from the ISFSIs of specific closed nuclear power plants. In the initial site-specific de-inventory reports, Orano performed a multiattribute utility analysis (MUA) to assess and identify favored routes and modes of transportation from ISFSI sites to a railroad hub located in the central U.S. and with connections to all other major rail routes. The hypothetical destination was used purely for planning and budgeting and does not imply a repository or interim storage facility will be located there.

To support the evaluation of the routes in the MUA, Orano used input from industry subject matter experts, along with data from the DOE's Stakeholder Tool for Assessing Radioactive Transportation (START) program. MUA assessments can be performed in the future with input from other stakeholders, either as a separate assessment or in combination with the existing assessment, to examine their preference on the feasible routes.

As of this writing, Orano has developed reports for six power reactor ISFSI sites, including Trojan, Humboldt Bay, Big Rock Point, Kewaunee, Maine Yankee, and Connecticut Yankee. Each report begins by examining the existing pertinent information for each site, including a description of the site and its characteristics, the characteristics of the SNF to be shipped from the site, and a description of the multipurpose canisters that would be shipped. A transportation route analysis was then performed to identify transportation routes from each ISFSI to a Class I railroad, which would then be used for subsequent shipment to a repository or interim storage facility.

Various routes and modes of transportation, including rail, barge, and heavy-haul truck, were assessed through the MUA and ranked from high to low according to their favorability, as established by industry experts. Based on the results from the MUA, a concept of operations and recommended budget and spending plan were detailed for the highest ranked shipment route. This assessment also includes information on a security plan and procedures, along with an emergency response and preparedness plan for the prospective shipments. Finally, the reports identify the next steps recommended for the process of initiating the removal of the SNF from each ISFSI.

The six site-specific de-inventory reports are technical reports of concepts that could support future decision-making by the DOE and, according to Orano, cannot be used to draw inferences on future actions by the department. To the extent the discussions or recommendations in the reports conflict with U.S. regulations, the provisions of Part 961 of Title 10 of the Code of Federal Regulations, *Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste,* prevail.

Results of the de-inventory reports are summarized below.

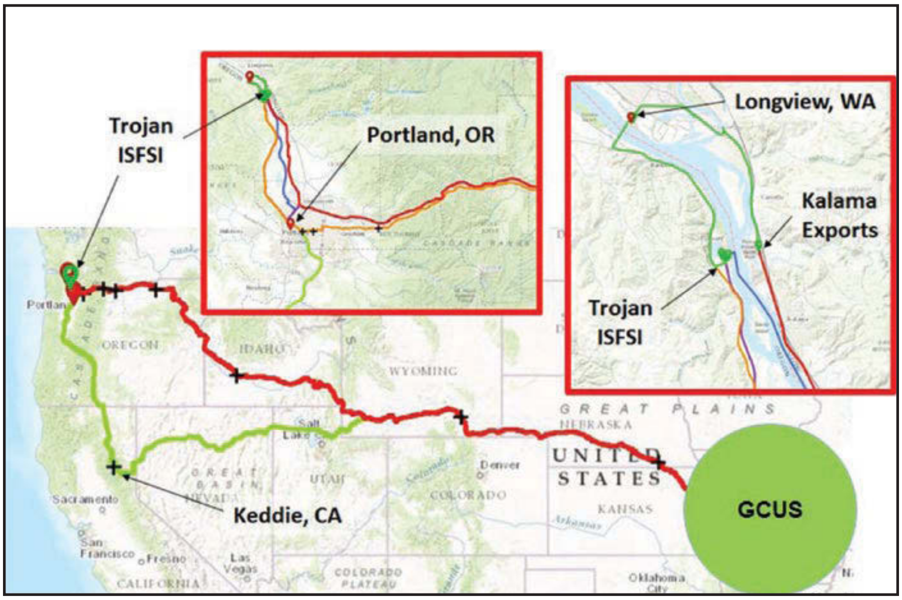


Fig. 1. Routes evaluated for the shipment of SNF from the Trojan site to a point in the geographical center of the U.S. (Image: Orano)

Trojan

The Trojan site is located in northwestern Oregon along the Columbia River, about 42 miles north of Portland, Ore. There is about 345 metric tons of uranium at the Trojan ISFSI currently loaded into 34 Holtec International multipurpose canisters stored in 34 TranStor concrete storage casks.

From the Trojan ISFSI site itself, direct rail transport from the site, as well as heavy-haul truck and barge transport to rail transfer sites, were considered viable options for the shipment of the SNF. The report evaluated six transportation routes (see Fig. 1). While a rail spur would need to be built to the Trojan ISFSI, the two routes with the highest ratings (based on average weighting method) were by railroad from the site following the Columbia River to the central U.S and by railroad via Keddie, Calif., to the central U.S. The routes with the least favored rating were by barge to a transfer facility in Portland and by truck to Portland. According to the report, the direct transfer of SNF to rail appears to be the least complicated approach, with the minimum number of times the SNF canister and overpack cask is handled, whereas the truck and barge scenarios appear to be more complicated, with multiple canister and cask handling activities.

Trojan's 34 SNF canisters would be loaded into HI-STAR 100 casks and transported over seven separate shipments, with five casks moved in the first six shipments and four casks in the last shipment. The ISFSI boundary will need to be extended to accommodate the transfer operations and loading of the HI-STAR 100 casks onto the railcars. The report estimates that the Trojan campaign would take more than 45 weeks (including one iteration for procedure writing, dry run, testing, and training purposes before the first shipment) at a cost of $11.8 million.

Humboldt Bay

Currently nearing the end of its decommissioning, the closed Humboldt Bay power reactor is located near the town of Eureka, Calif., about 260 miles north of San Francisco. The boiling water reactor's full inventory of SNF and GTCC waste has already been transferred to the site's ISFSI and is contained in six Holtec HI-STAR HB transportation casks. There are a total of 390 SNF

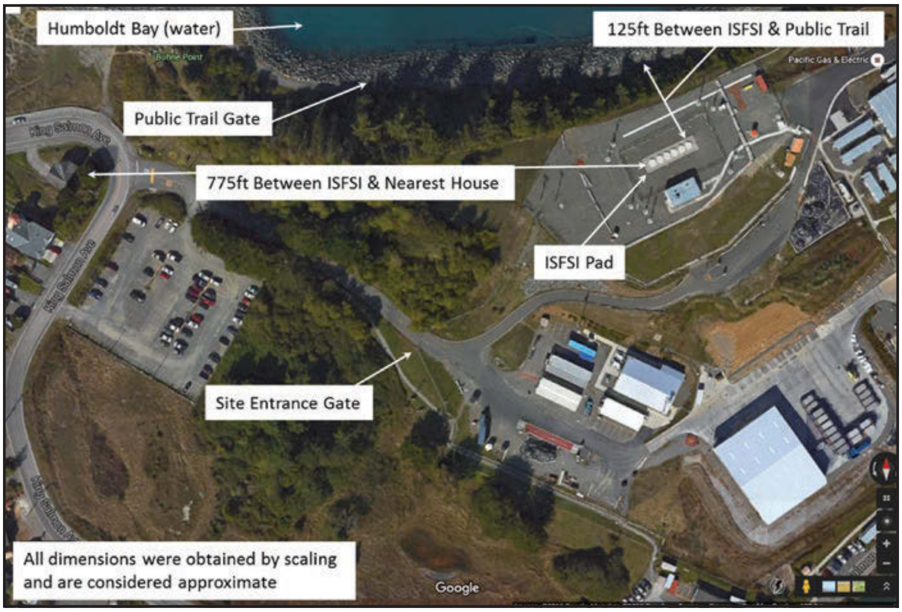


Fig. 2. Access points around the Humboldt Bay ISFSI. (Image: Orano)

assemblies and fuel debris loaded in five of the casks and the GTCC waste is loaded in the sixth cask.

While, as in the other reports, multiple modes of transportation were considered, the casks would need to be initially taken off the ISFSI site by truck due to the lack of direct access to rail and barge (Fig. 2). Of the eight transportation routes evaluated, the highest ranking route would take the SNF and GTCC waste by truck to Fields Landing about 1.5 miles south of the Humboldt Bay site, where it would be shipped by barge to Port Chicago in Concord, Calif., about 300 miles away near San Francisco. From Port Chicago, the casks could be transferred to railcars for rail shipment to the central U.S. location.

It would take an estimated 12 days to move all six casks from the ISFSI to Port Chicago and another 14 days to ship the casks by rail to their final destination. Based on the limited number of casks to be shipped, the report recommends a one-time movement of all six casks from the ISFSI. The total estimated budget for the Humboldt Bay campaign planned over five weeks (including one week of preparation before the first shipment) is $2.7 million.

Big Rock Point

The Big Rock Point site is located on the eastern shore of Lake Michigan, about 4 miles north of Charlevoix and 11 miles west of Petoskey, Mich. (Fig. 3). A boiling water reactor, the Big Rock Point nuclear power plant ceased operations in 1997 and its SNF and GTCC waste were moved to the ISFSI by May 2003 after the plant was decommissioned. There are a total of eight FuelSolutions W74 canisters loaded into W150 concrete storage casks on the ISFSI. The equipment needed to transfer the W74 canisters from the storage casks to a TS125 transportation cask is in place and is tested and maintained on a periodic basis, according to the report.

While Big Rock Point originally had rail access, the track and switches were removed in 1988 and the cost of reinstalling the approximately 20 miles of track would be prohibitive. Instead, the report recommends shipping the casks using a heavy-haul truck to one of two available railroad transfer sites in Petoskey (Clarion Avenue or Washington Street). From there the casks would go by rail to the central U.S. location via either Durand or Annpere, Mich. A barge route to a railroad transfer facility in Milwaukee was also evaluated but was the lowest ranked of the seven routes considered.

Transferring a W74 canister to a TS125 cask and preparing it for shipment will take about three days, while hauling the cask from the Big Rock Point ISFSI to the rail spur is estimated to take one day. Loading operations to transfer the cask from the transport trailer to the railcar will take another two days. The report's timeline of operations is broken down into eight transportation campaigns, with each campaign being a shipment of one single cask moving on one dedicated train. It is estimated that a single campaign will take 3.5 weeks. The total estimated budget to de-inventory the Big Rock Point site of SNF and GTCC waste organized over 36 weeks (about eight months) is $7.3 million.

Fig. 3. Access locations to the Big Rock Point ISFSI. (Image: Orano)

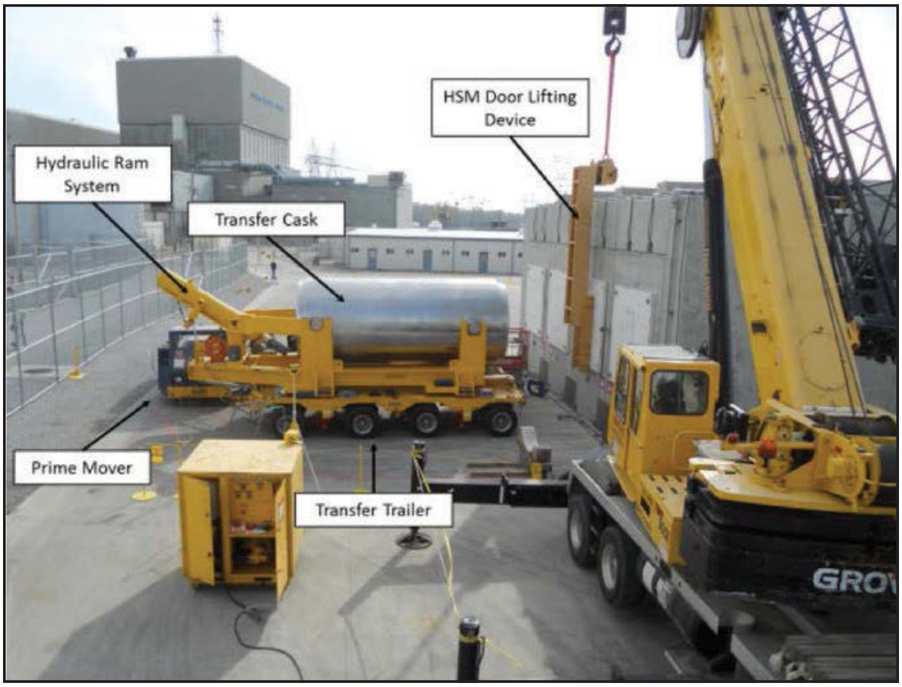


Fig. 4. Staged NUHOMS transfer equipment at the Kewaunee ISFSI. (Image: Orano)

and an actual selection will depend on the conditions of these routes and transfer sites when the time to ship grows near. The total estimated budget for the whole campaign organized over 56 weeks (about 13 months) is $19.3 million.

Kewaunee

Located in Carlton, Wis., about 30 miles southeast of Green Bay and 90 miles north of Milwaukee, the Kewaunee nuclear power plant ceased operations in May 2013 and is currently undergoing decommissioning under the NRC's SAFSTOR method. Transfer of the reactor's spent fuel to the ISFSI was completed in June 2017, and it is estimated that two canisters of GTCC waste will be loaded onto the ISFSI in the near future. There are two storage systems in use on the Kewaunee ISFSI, including 14 NUHOMS horizontal storage modules supplied by TN Americas (Fig. 4) and 24 NAC MAGNASTOR vertical concrete casks from NAC International. The 14 NUHOMS dry storage canisters contain a total of 448 SNF assemblies, while the 12 MAGNASTOR canisters contain 887 SNF assemblies. The canisters would be shipped to their final destination using the TN MP197HB and NAC MAGNATRAN transport casks, respectively.

For shipping the SNF from the Kewaunee ISFSI to a railcar on a Class I railroad that can take the SNF to its final destination, the MUA ranked five routes. In the highest ranked route, the SNF would by transported by truck from the ISFSI to a rail transfer site in Green Bay, and then travel by rail on the Canadian National Railway south along the Fox River toward Chicago, and then to the central U.S. This route was slightly favored over the second ranked route, which would ship the SNF by barge to the Port of Milwaukee, where it would be loaded onto a Union Pacific train. This route was ranked lower primarily due to public resistance to shipping radioactive materials by barge on the Great Lakes.

The following two routes also were closely ranked, and according to the report, the slight difference between the top four routes indicate that there are multiple viable, similar routes from Kewaunee,

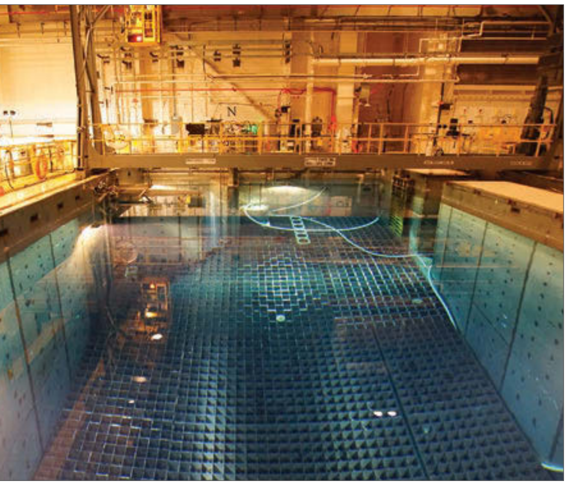
Maine Yankee

The Maine Yankee site is located in the midcoast region of Maine, about 25 miles south of Augusta and 45 miles northeast of Portland. Once the home of a 931-MWe pressurized water reactor power plant, which ceased operations in December 1996, the site license was reduced to just the ISFSI in 2005. The inventory of SNF and GTCC waste intended to be shipped from Maine Yankee is contained in 64 NAC International Universal Multi-Purpose Canister System (UMS) storage units, which includes transportable storage canisters and vertical concrete casks. There are a total of 1,434 SNF assemblies and fuel debris loaded in 60 UMS units, and GTCC waste is loaded in the remaining four UMS units.

The highest of six ranked routes would use an on-site rail spur, which has been partially paved over and would require some refurbishment (Fig. 5). The casks would be moved by rail about 135 miles to Worcester, Mass., where an interchange between the Class II rail carrier and the Class I carrier would take place. The casks would then go by rail to their final destination. A truck and trailer would be needed to first move the casks to the on-site rail spur, which is about 500 feet from the gate of the Maine Yankee ISFSI.

The SNF and GTCC waste would be transported in 13 round-trip shipments of five UMS universal transport casks over a period of six weeks each. An additional six weeks of planning and preparation also would be needed before the start of the first campaign. The total estimated budget for the Maine Yankee

Fig. 5. The condition of the railroad spur at Maine Yankee. (Photo: DOE)



Radwaste SOLUTIONS

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In the United States, this business is centered around the following industry subsets: (1) the Department of Energy's remediation of its weapons production and research facilities; (2) civilian radioactive waste activities, including low-level waste disposal, the onsite storage of used nuclear fuel and high-level waste, and efforts to develop a deep geologic repository; (3) the management of waste from operating nuclear power plants and the decommissioning of plants no longer in operation, and (4) nonpower, non-DOE activities.

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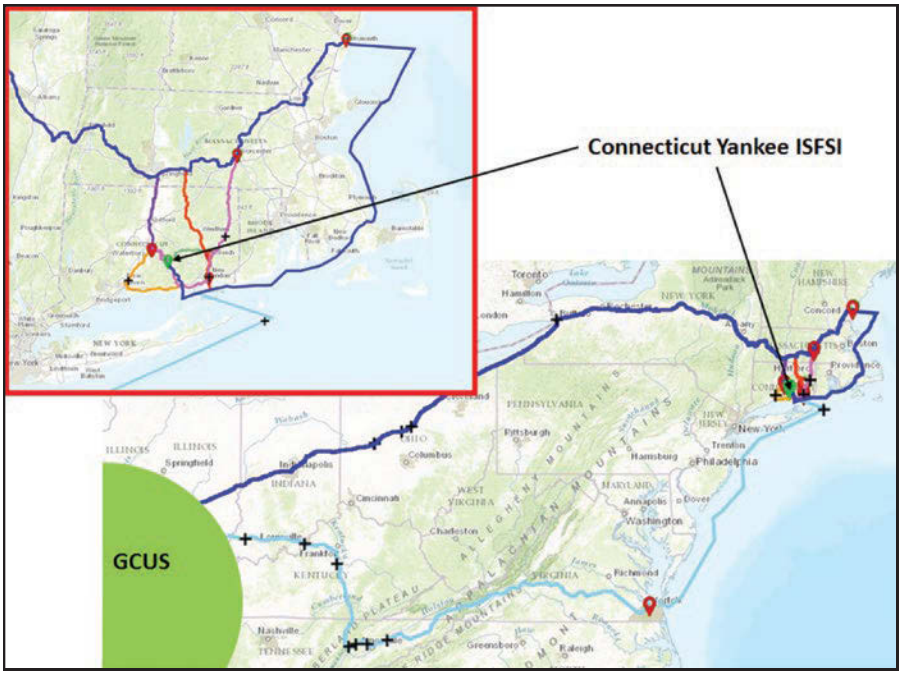

Fig. 6. Routes evaluated for the shipment of SNF from Connecticut Yankee to the central U.S. (Image: Orano)

campaign organized over 84 weeks (about 19 months) (including one iteration for procedure writing, dry run, testing, and training before the first shipment) is $24.1 million.

Connecticut Yankee

Similar to Maine Yankee, the Connecticut Yankee nuclear power plant ceased operations in 1996, and the site license is limited to the 5.7 acres the ISFSI occupies. Located on the eastern shore of the Connecticut River near Haddam Neck, Conn., the site is about 13 miles southeast of Middletown and 25 miles southeast of Hartford. There are 43 storage casks at the Connecticut Yankee ISFSI, with 40 of the casks containing SNF and three containing GTCC waste. For shipping, the NAC International multipurpose canisters holding the SNF and GTCC waste would be loaded into NAC Storable Transport Casks.

As the Connecticut Yankee site is not served by rail, the three highest ranked routes would all transport the casks by heavy-haul truck from the ISFSI to a rail transfer site in Portland, Conn., about 13 miles away. In the first route, the casks would travel by rail southwest from Portland to New Haven, then to the Worcester, Mass., interchange before moving on to the central U.S. Rail routes southeast through New London and northwest through Hartford were also highly ranked. Of the seven routes evaluated (Fig. 6), the three lowest ranked routes would ship the casks by barge to railroad sites in New London; Portsmouth, Maine; and Norfolk, Va., respectively.

Campaign operations would be broken down into eight round-trip shipments of five casks and one one-way shipment of three casks over a period of six weeks each. An additional eight to nine weeks of planning and preparation would be needed before the start of the first campaign. The total estimated budget for the entire Connecticut Yankee campaign organized over 60 weeks (about 14 months) is $17 million.

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The Path to Cleanup

Budgets, politics, safety, and a 45-day EM review were all topics of discussion during the 2017 National Cleanup Workshop.

While it will be decades before all of the country's legacy waste sites are satisfactorily remediated, many of the speakers at the Energy Communities Alliance's third-annual National Cleanup Workshop were notably upbeat about meeting the mission goals of the Department of Energy's Office of Environmental Management (EM), which is responsible for the cleanup and management of defense-related nuclear waste.

Contributing to the elevated mood may have been EM's proposed $6.5-billion budget for fiscal year 2018—its biggest budget in a decade—or the appointment of a new energy secretary, Rick Perry, whom many of the speakers lauded as a team player focused on getting results. Regardless, about 660 attendees participated in the workshop, the year's largest EM–focused gathering in the Washington, D.C., area, according to the DOE.

Held September 12–14 in Alexandria, Va., in cooperation with the DOE and the Energy Facility Contractors Group, the National Cleanup Workshop brought together senior DOE executives, officials from DOE sites, industry executives, local officials, and other stakeholders to discuss EM's progress in meeting its cleanup goals.

The workshop's keynote address was delivered by Dan Brouillette, the recently appointed deputy secretary of energy, who began by noting the strong bipartisan support in Congress for EM and its mission. Speaking as the former chief of staff to the House Energy and Commerce Committee, he said that committee members are passionate about the EM program. Brouillette added that he was excited about working with Secretary Perry, with whom he has previously worked. "We are a team," he said. "We work well together."

As far as the DOE's current priorities, Brouillette said that the common thread for EM and the National Nuclear Security Administration is the department's responsibility surrounding the nation's nuclear arsenal, with the goals of advancing national security and ensuring a cleaner environment. Noting that the Trump administration is seeking an 11 percent increase in the NNSA's FY 2018 budget, Brouillette said that defending the country's safety and security through nuclear deterrence is a moral imperative, and that cleaning up the nuclear waste resulting from those activities is a "moral necessity."


Brouillette

"The communities that helped us win the Cold War and help us keep the peace today answered the call to their nation," he said. "It is now our turn to answer their call to clean up this legacy and provide these communities with a brighter tomorrow."

Brouillette said that he witnessed some of the progress EM is making in cleaning up legacy waste during a recent visit to the Hanford Site near Richland, Wash., where headway is being made on the construction of the Waste Treatment and Immobilization Plant and the demolition of the Plutonium Finishing Plant, which is in its final stages. Much more work remains to be done, however, and the DOE's goal is to put its cleanup mission on a final path to complete the cleanup "sooner, safer, and at less cost to the taxpayers," he said.

Doing so will require a sustainable approach to cleanup programs that minimizes risks while seeking ways to shorten schedules and lower project costs, Brouillette said, adding that one of his highest priorities as deputy secretary of energy is the streamlining of regulations, with the goal of improving overall efficiency without sacrificing safety or quality. This, he said, includes everything from improving internal DOE policy to enhancing relationships with regulators. Brouillette also noted that President Trump's $6.5-billion EM budget request sends a positive signal to the EM workforce, site host communities, and other stakeholders.

U.S. House leadership

While the EM budget request can be seen as a positive sign, Congress still holds the purse strings, and any final budget will need to go through the appropriations process. Rep. Chuck Fleischmann (R., Tenn.) spoke about his role as a congressman and appropriator, as well as the chairman of the House Nuclear Cleanup Caucus.

Fleischmann, a member of the House Appropriations Committee's Subcommittee on Energy and Water Development, voiced his commitment to maintaining a strong EM program. "It's about funding, funding, funding," he said. "You have to have the dollars to make sure you can complete the mission." He followed that statement, however, with the observation that the country is in a very tight and competitive fiscal environment.


Fleischmann

In addition to funding, completing the decades of remaining cleanup work will require cooperation among federal, state, and local partners, as well as more efficiency on the part of government contractors, Fleischmann said. As an example, he said that UCOR, the DOE's cleanup contractor for the Oak Ridge Reservation, did an excellent job of using federal money efficiently to take down the site's Gaseous Diffusion Plant buildings. "They were under budget and on time," he said.

Regarding the budget process itself, Fleischmann said that the House has been doing a good job this year in pushing the budget forward. He noted that the 2018 Energy and Water Development Bill, which provides $6.4 billion for environmental management activities, was introduced in July, and he added that he was confident that all 12 House appropriations bills would be completed in 2017. (The House on September 14 passed a $1.2-trillion omnibus bill that combined all 12 appropriations bills.)

Fleischmann also said that as a "generic member of Congress," he believes he has a responsibility to talk about and advocate for the EM program. Returning to the example of Oak Ridge, which is in his district, he said that cleaning up DOE sites paves the way for economic development. This is demonstrated by the East Tennessee Technology Park, he said, which is reindustrializing the former Gaseous Diffusion Plant site. To continue redevelopment at Oak Ridge and other DOE sites, Fleischmann said that he predicts that there will be more engagement by the private sector in the DOE's mission, as well as a continued commitment by Congress and the White House to fund EM projects.

Finally, Fleischmann spoke about his work leading the House Nuclear Cleanup Caucus, which he said is fast becoming one of the biggest caucuses in Congress. His role in the caucus is different from his role as an appropriator, he said, in that the caucus is able to reach out and work with both authorizers and appropriators. That is, it involves people who authorize federal cleanup projects and those who set the funding for the projects. Emphasizing the importance of the caucus, Fleischmann asked the audience to reach out to their representatives in Congress and insist that they get involved. "This is one area where you can have tremendous impact," he said.

More budget talk

During day two of the workshop, the topic of EM's budget was picked up and expanded on by Rep. Mike Simpson (R., Idaho), who revealed in further detail some of the sausage making that goes on in Congress when putting together an appropriations package.

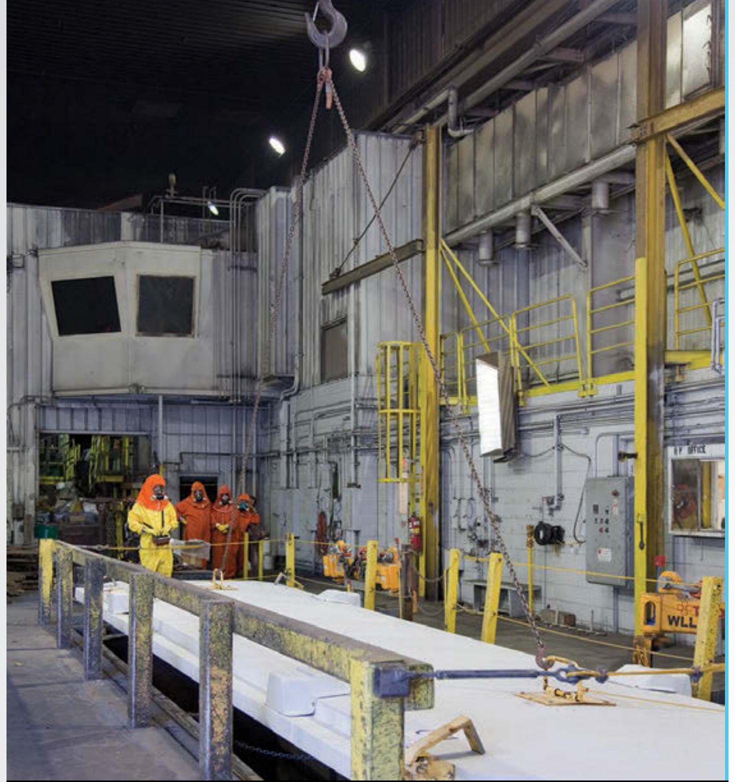
Simpson, who is chairman of the Energy and Water Development Subcommittee, noted that the Trump administration did not submit a budget to Congress until May, and that the budget it did submit contained little detail. "That put us behind the 8-ball, frankly," he said, adding that there was little time for budget hearings and other oversight measures.


Simpson

In its Energy and Water Bill, the House rejected a lot of the administration's budget proposals, Simpson said. Every administration, he explained, cuts funding for programs it knows Congress will fund and puts it into programs that it wants funded. As an example, he pointed to the U.S. Army Corps of Engineers, which would see a reduced budget under the president's proposal. "Every member of Congress has an Army Corps of Engineers project somewhere in their district," he said. "So when you try to cut a couple billion dollars out of the Army Corps of Engineers, that's not going to fly."

Simpson said that the House budget

Transportation & Logistics



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puts about $2 billion back into the Army Corps of Engineers' budget and increases defense spending by about $1 billion. That money, he said, will have to come out of other DOE programs, including a reduction in funding for the Energy Efficiency and Renewable Energy (EERE) initiative and the elimination of the Advanced Research Projects Agency–Energy (ARPA-E) program. Simpson said that reducing the EERE budget was not something that he wanted to do, but he agreed with the elimination of ARPA-E, saying that it will allow the DOE to refocus on basic research.

> ***Simpson said that if the Senate does not approve any money for Yucca Mountain, it is certain that the House will not pass an interim storage bill.***

The main challenges the EM program faces, Simpson said, are the same ones it has faced for the last five or more years—namely, what to do about the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) at the Savannah River Site and how to move forward on the Yucca Mountain repository project and the consolidated interim storage of spent nuclear fuel. Simpson said that he has met with Sen. Lamar Alexander (R., Tenn.) and Secretary Perry to discuss these projects but they were unable to reach any agreements.

Regarding the MFFF, which is intended to convert surplus weapons-grade plutonium into nuclear fuel for commercial use, Simpson said that the DOE's current plan of abandoning the project for a "dilute and dispose" option raises a lot of unanswered questions. He said that it is still not known what the full costs of disposal would be, or whether the Waste Isolation Pilot Plant (WIPP) would need to be expanded to accommodate the plutonium, or if Russia, which was part of the MOX agreement, would accept the disposal alternative.

Simpson said he doesn't want a future chairman of the Energy and Water Subcommittee to be held hostage to a decision made today with incomplete information and without a clear path forward. He added that abandoning the MFFF would be walking away from a lot of money. According to the DOE's most recent performance baseline, over $4.6 billion has already been spent on constructing the MFFF. That baseline also puts the estimated total project cost at between $9.9 billion and $17 billion.

As for Yucca Mountain and the possibility of a national interim storage program, Simpson said that following the election, he and other lawmakers were confident that a resolution would be found. "But now we are back to the same situation," he said. Simpson explained that it will be difficult to get anything done, because Republicans in the Senate hold only a two-seat majority, one of which is occupied by Sen. Dean Heller (R., Nev.), who is opposed to the Yucca Mountain Project. Simpson said that he wasn't sure if Senate Majority Leader Mitch McConnell (R., Ky.) will be willing to risk Heller's support by pursuing Yucca Mountain.

The Senate and the House have long been at loggerheads regarding Yucca Mountain and consolidated interim storage, with the House wanting to make any interim storage program contingent on moving Yucca Mountain forward, while the Senate has been willing to decouple the two programs. Simpson said that if the Senate does not approve any money for Yucca Mountain, it is certain that the House will not pass an interim storage bill.

EM 45-day review

At the time of the workshop, the Trump administration had yet to nominate an assistant secretary for EM. In the interim, James Owendoff was appointed in June to serve as EM's acting assistant secretary. Shortly after taking the position, Owendoff, who had served as a senior advisor to the EM assistant secretary since 2010, initiated a 45-day review to identify opportunities to improve the effectiveness and execution of the legacy waste cleanup program.


Owendoff

Owendoff said that it was his intention to get the EM team, including site managers and headquarters staff, to address the pressing program decisions that need immediate attention and identify those issues that require further analysis. "It's not a budget drill," he said. "It's not about [getting] more money; $6.5 billion is a heck of a lot of money."

One such decision, Owendoff said, is whether to grout the underground waste tanks at the Hanford Site, similar to what was done at the Savannah River Site, and what would need to be done to implement that decision. "I am not making the decision to do that," he said. "I'm just saying [it's] a decision that I believe we need to tee up and look at viable alternatives." He added that any investigation of alternative actions would need to include a cost analysis.

Owendoff said that the review is meant to be a starting point and to serve as a mechanism to energize site managers and DOE staff to take on tough decisions and look at viable alternatives without delaying further action. Subsequently, the department will begin publicizing the key decisions it has identified and engaging with local communities, elected officials, regulators, and other stakeholders to gather their input, he said.

When asked by an audience member what EM is considering, Owendoff stressed that EM does not intend to publish a list of things it intends to accomplish. This was repeated during a later session, where Owendoff said that the review is not meant to create a national list, as the considered decisions will be specific to each site, and final decisions will be made internally. Publishing a formal list would create "all kinds of back and forth, and we would lose focus," he said.

Moving forward on making those decisions and getting things done, however, will require cooperation from everybody, Owendoff said. As EM's acting assistant secretary, he said that he plans to engage with site managers and DOE staff to help advance cleanup goals, adding that EM has the ability to put in place a sense of urgency among the federal and contractor workforce.

Owendoff also briefly mentioned the use of technology and innovation to accomplish cleanup work, saying that EM will need to take an earnest look at when new technologies are needed and when "brute force" will suffice. Asked by an audience member to clarify his statements on technology, Owendoff said that it is not a "one size fits all" situation. "In my bias for action, I don't want to chase a technology if what we have can get us there," he said.

Ensuring safety

Sean Sullivan, chairman of the Defense Nuclear Facilities Safety Board (DNFSB), raised the question of how best to ensure safety at defense cleanup sites and discussed the relationship between safety and accountability. "To ensure safety, we need a strong culture of accountability at defense cleanup sites," he said.

In distinguishing between the cultures of safety and accountability, Sullivan said that a culture of accountability encompasses a broader set of standards. "It is about leadership, doing the right thing, making the right decisions, holding others to high standards, and holding yourself and others to account when failures do occur," he said, adding that the standard of accountability must be higher for defense nuclear sites than other, nonnuclear, endeavors.

Sullivan also made the distinction between oversight and accountability, saying that he considered oversight to be like a bandage on a wound. A bandage can prevent infection and promote healing, he said, but if the wound is already infected, the wound will fester no matter how much it is bandaged. As an example, he said that there was plenty of oversight of waste processing at Los Alamos National Laboratory—by the DOE, the state of New Mexico, and the DNFSB—and yet transuranic waste still had been improperly packaged, causing the radiological release at WIPP in February 2014.


Sullivan

When it comes to responsibility, Sullivan said that society typically holds people accountable not for their actions, but rather for the consequences of those actions, even when the consequences are the result of many independent factors. As a hypothetical, he asked the audience to consider a scenario in which a man fires a loaded gun into the air in a public place. There are three possible outcomes from this action, Sullivan said. The gun jams and nothing happens, in which case there is little or no accountability; the gun fires but the bullet falls harmlessly to the ground, resulting in a possible firearms violation; or the bullet falls, striking and killing a bystander, in which case the man may be tried for manslaughter.

"To be sure, he has been reckless," Sullivan said of the hypothetical man. "Yet the accountability that society will demand for that recklessness will depend on what happens after he squeezes the trigger, even though everything that happens is independent of the man himself."

Applying this to the real world, Sullivan said that any number of independent factors could have changed the outcome of the 2014 radiological accident at WIPP, for either better or worse. It is possible, he said, that the transuranic waste drum that caused the accident never would have breached, or that it could have breached while still aboveground, or with workers nearby. In each case, Sullivan rhetorically asked, would the accountability demanded have been lesser or greater?

Another aspect of accountability that Sullivan brought up was the question of who is held accountable when something does go wrong. Here Sullivan recounted a conversation he had with nuclear engineer and ANS past president (1983–1984) Milton Levenson. According to Sullivan, Levenson said that the difficulty of ensuring safety through accountability in the modern era is a result of responsibility being "diffused amongst many people." In the past, Sullivan said, accountability primarily resided with an individual safety officer, who was responsible for all aspects of safety. Today, such work is spread out among many people, increasing the odds that any one person may make a mistake. Sullivan also compared this diffused responsibility to the psychological phenomenon known as the bystander effect, where the more people there are witnessing something go wrong the less likely any one will take action.

Who is held accountable and to what degree are difficult questions, Sullivan said. While maintaining that the standards of accountability must be high and everyone should be held accountable to the appropriate degree, Sullivan said that how high and how much depend on the facts of each individual case. "There is no cookbook to follow," he said. "In the end, difficult decisions need to be made by leadership, and if that wasn't the case, we wouldn't need any leaders."—*Tim Gregoire*

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Moving Up

People in the news

Jan Carlin has been named managing director of Waste Management Symposia, a nonprofit organization dedicated to providing education and information exchange on global radioactive waste management. Carlin will continue in her role as director of business development for the German company Wälischmiller Engineering GmbH.


Carlin

Bernard Fontana has been appointed chairman and chief executive officer of Framatome, and **Philippe Braidy** has been appointed managing director. Fontana most recently served as CEO of Areva NP, and Braidy most recently served as manager of finance, strategy/innovation/communications, legal/compliance, risks/audit, and information systems at Areva NP.


Fontana


Braidy

Dan Sumner has been named chief financial officer of Westinghouse Electric Company. Sumner joined Westinghouse in 2010, and prior to being named acting CFO in May, he served as vice president of finance with responsibility for global product line and region finance, financial planning and analysis, corporate accounting, and global shared services. **Ken Canavan** has been appointed chief technology officer for Westinghouse Electric Company. Canavan, who has more than 30 years of experience in key engineering and risk management roles, was previously director of engineering for the Electric Power Research Institute.


Summer


Canavan

Michael S. McGough has joined Saulsbury Industries, a privately owned engineering, procurement, and construction firm, as chief nuclear officer to lead its nuclear services business. McGough joins Saulsbury from NuScale Power, where he served as chief commercial officer since 2011. He is a 38-year veteran of the commercial nuclear industry, supporting construction, operations, maintenance, and decommissioning of nuclear plants worldwide.


McGough

Camilla Hoflund has been appointed president and chief executive officer of Studsvik, a Swedish supplier of advanced technical services for the international nuclear power industry. She replaces **Michael Mononen**, who had served as president and CEO for five years. Hoflund joined Studsvik in 1994 and most recently was president of fuel and materials technology. **Joakim Lundström** has been appointed head of the Fuel and Materials Technology business area and member of the Executive Management Group for Studsvik. Lundström will also continue in his role as president of Studsvik Nuclear, which houses the Fuel and Materials Technology operations and nuclear facilities.

Scott Eckler has joined packaging, transportation, and logistical management company ICE Packaging Company/Strategic Packaging Systems (SPS) as general manager of SPS. Eckler previously spent 19 years in various positions with Veolia Alaron Nuclear Services and has over 35 years of experience in the nuclear industry in numerous areas, including health physics, health and safety, and radiological waste characterization and disposition, packaging, and transportation.


Eckler

John W. "Bill" Pitsea has joined the Nuclear Energy Institute as chief nuclear officer. He joins NEI as a loaned executive from Duke Energy, where he was senior vice president and CNO. **Joe Pollock**, who has served as interim CNO since January 2017, will return to the position of vice president of nuclear generation, which he has held since 2013.


Pitsea

BWX Technologies (BWXT) has named **Kenneth Camplin** president of the Nuclear Services Group, and **Regina Carter** senior vice president of government affairs and communications. Camplin will continue to oversee BWXT's business development operations, and Carter will continue to serve as a member of BWXT's executive staff and strategic planning team.

Ken Langdon has joined NuScale Power as vice president of operations and plant services. Langdon comes to NuScale from Westinghouse, where he was vice president and deputy project director at the Summer nuclear power plant, as well as vice president of operational readiness in Shanghai, China, for the first two AP1000 plants in the world.


Langdon

Peter Hosemann has been elected chair of the Nuclear Science User Facility (NSUF) User Organization, where he will be the liaison between NSUF users and facilities and NSUF management. Hosemann is an associate professor in the Department of Nuclear Engineering at the University of California at Berkeley.


Hosemann

Scott Head has joined Certrec as business development director in its Office of Licensing and Compliance. Head recently retired from STP Nuclear Operating Company, where he was responsible for all safety and environmental activities performed to support obtaining and maintaining the combined operating licenses for South Texas Project-3 and -4.

DOE

Paul Dabbar has been confirmed by the Senate as undersecretary for science at the Department of Energy. Dabbar, who was previously head of energy mergers and acquisitions at J.P. Morgan, has experience with investments and transactions in renewable energy, oil and gas production, nuclear energy, mining, efficiency, and the electric grid.


Dabbar

Terry C. Wallace has been named director of Los Alamos National Laboratory and president of Los Alamos National Security, the company that manages and operates LANL for the National Nuclear Security Administration. He replaces **Charles F. McMillan**, who has retired. Wallace most recently served as principal associate director for global security at the laboratory, leading programs with a focus on applying scientific and engineering capabilities to address national and global security threats, nuclear threats in particular.


Wallace

Anne M. White has been nominated to be assistant secretary of environmental management in the Department of Energy. White is the founder of Bastet Technical Services, a consulting firm that provides "strategic solutions to solve complex environmental challenges across the Department of Energy complex," according to a White House press release.

Brian Reilly has been named project director for the Waste Treatment and Immobilization Plant project at the Department of Energy's Hanford Site. He succeeds **Peggy McCullough**, who has moved to Bechtel's operational headquarters in Reston, Va., to lead the company's nuclear, security, and operations business line. Since 2014, Reilly led the design and construction project for the National Nuclear Security Administration's Uranium Processing Facility in Oak Ridge, Tenn.

John Wagner has been named associate laboratory director for the Nuclear Science and Technology (NS&T) Directorate at Idaho National Laboratory. He previously was director of NS&T domestic programs and the Technical Integration Office for the Light Water Reactor Sustainability Program in the Department of Energy's Office of Nuclear Energy. Prior to joining INL in 2016, Wagner was director of the Reactor and Nuclear Systems Division at Oak Ridge National Laboratory.

Wagner

NRC

K. Steven West has been appointed administrator of the Nuclear Regulatory Commission's Region II office, which provides nuclear regulatory oversight in the Midwest. West was previously acting director of the NRC's Office of Nuclear Security and Incident Response.

West

The Nuclear Regulatory Commission has announced the appointment of two office directors. **Mary C. Muessle** has been appointed director of the Office of Administration, and **Anne T. Boland** has been named director of the Office of Enforcement. Muessle, who joined the NRC in 2003, most recently was the commission's deputy chief financial officer. Boland, who joined the NRC in 1985, previously was director of the Division of Operating Reactor Licensing in the Office of Nuclear Reactor Regulation.

Muessle

Utilities

Keith Polson has been appointed senior vice president and chief nuclear officer of DTE Energy. He succeeds **Paul Fessler**, who has retired after 41 years with the company. Polson most recently was vice president of nuclear generation for DTE Energy. Prior to joining the company in January 2016, he was the site vice president at the Tennessee Valley Authority's Browns Ferry nuclear plant.

Polson

Chris Church has been named site vice president at the Monticello nuclear power plant in Minnesota. Church joined plant owner Xcel Energy in January as general manager of nuclear fleet operations. He was previously vice president of operations support for the Tennessee Valley Authority.

Church

James Welsch has been named chief nuclear officer of Pacific Gas and Electric Company (PG&E), and **Jon Franke** has been named vice president of power generation. Welsch, who joined PG&E in 1984, will also continue in his role as vice president of nuclear generation. Franke, who joined the company in January, previously served as vice president of generation technical services.

Welsch

FirstEnergy Nuclear Operating Company (FENOC) has announced a number of leadership changes. **Richard Bologna** has been promoted to vice president of the Beaver Valley nuclear power plant in Shippingport, Pa., and **John Grabnar** has been named general plant manager at Beaver Valley, the position most recently held by Bologna. **Brian Boles** has been promoted to vice president of nuclear support for

FENOC's nuclear fleet, and **Mark Bezilla** has been promoted to vice president of the Davis-Besse nuclear power plant in Oak Harbor, Ohio, the position most recently held by Boles. **Terry Brown** has been named vice president of fleet oversight, the position most recently held by Bezilla, and **Doug Huey** has been promoted to director of performance improvement.

Barry Blair has been named general plant manager of FirstEnergy Nuclear Operating Company's Davis-Besse nuclear power station near Oak Harbor, Ohio. Blair most recently served as manager of operations at FirstEnergy's Perry nuclear power plant near North Perry, Ohio.


Blair

Ed Burchfield has been named site vice president of the Oconee nuclear power station near Seneca, S.C. He previously served as the Oconee plant manager, a role he had held since September 2016.

James E. Brogdon Jr. has been named interim president and chief executive officer of Santee Cooper, and **Marc R. Tye** has been named chief operating officer. Brogdon, who retired from Santee Cooper in 2014 as general counsel and executive vice president, replaces **Lonnie Carter,** who announced in August that he would retire once an interim replacement was found. Tye was previously the utility's executive vice president of competitive markets and generation.


Brogdon


Tye


Carter

John Christensen has been elected president and chief executive officer of the Utilities Service Alliance (USA), a non profit cooperative designed to facilitate collaboration among its member utilities in the commercial nuclear power industry. Christensen, who joined USA in 2007 as strategic sourcing manager, was promoted in 2013 to vice president of operational performance and has been serving as acting president and CEO since February.


Christensen

International

Teodor Chirica has been appointed president of Foratom, the Brussels-based trade association for the European nuclear energy industry, and **Esa Hyvärinen** has been appointed vice president. Chirica continues to serve on the executive board, which he joined in 2006, and as a member of the advisory board of the Romanian Energy Center. Hyvärinen is senior vice president of corporate relations for Fortum Corporation.

Horizon Nuclear Power, the U.K. subsidiary of Hitachi Ltd., has announced the appointment of **Rabih Hafez** as project

planning unit director and **James Jones** as general counsel and company secretary. Hafez, who has over 34 years of international experience in the nuclear industry, most recently was senior project manager for the Mochovce nuclear power plant in Slovakia. Jones, who has 25 years of industry experience, was principal counsel for Horizon prior to his new appointment.


Pershukov

Rosatom, Russia's state atomic energy corporation, has named **Vyacheslav Pershukov** special representative for international, science, and technology projects. Pershukov was previously Rosatom's deputy director general for innovation management.

Toyoshi Fuketa is the new chairman of Japan's Nuclear Regulation Authority (NRA). He succeeds Shunichi Tanaka, who stepped down when his term expired in September. Fuketa has been a member of the NRA since it was formed in 2012. Before joining the NRA, he served as deputy director general of Japan Atomic Energy Agency's Nuclear Safety Research Center.


Fuketa

Mark Foy has been appointed chief nuclear inspector for the United Kingdom's Office for Nuclear Regulation (ONR) for an initial fixed term of five years. Foy, who succeeds **Richard Savage** in this position, most recently served as deputy chief inspector and director of operating facilities at ONR.


Foy

Jungmin Kang has been named chairman of South Korea's Nuclear Safety and Security Commission. Kang is currently a senior research fellow in the U.S. Natural Resources Defense Council's Energy and Transportation program. ■


Kang

It's Business

Contracts, business news, etc.

Business developments

Toronto, Ontario–based **Brookfield Business Partners** announced on January 4 that it has agreed to buy **Westinghouse Electric Company** from parent company **Toshiba** for approximately $4.6 billion. Westinghouse filed for Chapter 11 bankruptcy protection in March 2017 as a result of losses from the Summer and Vogtle nuclear construction projects.

According to Brookfield, the purchase will be financed through approximately $1 billion of equity and about $3 billion of long-term debt financing. The remaining balance of the purchase price will be covered by Brookfield's assumption of certain Westinghouse obligations, including pension, environmental, and other operating costs. Brookfield's acquisition of Westinghouse is expected to close in the third quarter of 2018, subject to approval by the bankruptcy court and customary closing conditions, including regulatory approvals. Westinghouse said that throughout the process, it will continue to operate in the ordinary course of business under its existing senior management. Westinghouse had hoped to exit bankruptcy by the end of March.

The international energy services company **Wood Group** announced on Oct. 9, 2017, that it has completed its acquisition of the British consulting, engineering, and project management company **Amec Foster Wheeler** in an all-share transaction worth £2.2 billion (about $2.9 billion). Robin Watson, chief executive of Wood Group, said in a statement, "This transformational acquisition creates a global leader in the delivery of project, engineering, and technical services to energy and industrial markets." Operating in more than 60 countries, Wood Group provides services from design concept to decommissioning across a range of industries and markets, including oil and gas, environment and infrastructure, power and process, mining, and nuclear.

In December, Toronto, Ontario-based **Kinectrics**, a privately owned, global provider of integrated life-cycle services to the electric power industry, completed its acquisition of the Nuclear Americas businesses from **Wood Group**. Wood agreed in November 2017 to sell its North American nuclear operations to Kinectrics for about Can$10 million (about $7.9 million) in cash. Kinectrics also later closed on the purchase of Wood's Nuclear Romania business.

Holtec International announced on Sept. 12, 2017, that it has officially opened the Krishna P. Singh Technology Campus in Camden, N.J. According to the company, senior international, local, and New Jersey state officials joined more than 700 assembled county residents, members of the media, and Holtec's professional staff for a ribbon-cutting ceremony for the opening of the campus, which is named in honor of Holtec's founder, president, and chief executive officer, Krishna P. Singh. The nearly 50-acre campus features a large manufacturing plant, a light manufacturing plant, and a seven-story engineering office building. Singh said the new campus would be ground zero for the renaissance of nuclear energy and heavy manufacturing in America.

Used fuel

On Sept. 25, 2017, **Holtec International** announced that it has been awarded contracts to provide spent nuclear fuel dry storage and transportation services to Brazil's Angra and Spain's Cofrentes nuclear power plants.

According to the company, Brazil's Eletronuclear-Eletrobrás Termonuclear awarded a turnkey contract to Holtec that includes the supply of the company's HI-STORM FW systems and related equipment for the dry storage of spent fuel from Angra-1 and -2. Modifications to the cask handling cranes and loading services for emplacing the fuel in the canisters and for moving them to the dry storage facility, to be designed and built by Holtec, will also be covered under the contract. While the different architectures and licensing bases of the two Angra units add to the complexity of the project, the company said that its implementation plan will allow for the use of similar equipment and operational procedures.

The Cofrentes contract was awarded by Enresa, Spain's radioactive waste management organization, and is for the order of dual-purpose storage and transport casks from Holtec. The casks will be used in the near term for on-site spent fuel storage at Cofrentes, after which they will be integrated into Enresa's fleet of transport casks for moving fuel to its planned centralized interim storage facility. Constrained by handling limitations at the plant, Holtec said that the cask for Cofrentes is a lighter and lower capacity version of its HI-STAR 180 series of casks, two models of which have been licensed by the Nuclear Regulatory Commission in the past decade and are earmarked for use in Switzerland and Belgium. The HI-STAR model for Cofrentes will be licensed for storage and transport by Spain, Holtec said.

D&D

BWX Technologies (BWXT) announced on Sept. 26, 2017, that its **BWSR LLC** joint venture with **APTIM** has been awarded a two-year, $140-million decommissioning contract extension by Bechtel Marine Propulsion Corporation (BMPC). According to the company, the award is inclusive of a $14-million option anticipated to be awarded in 2018 and includes an additional option for a third year of work at a value to be negotiated at a later date. Since October 2010, BWSR has performed comprehensive decommissioning and demolition and infrastructure support work on complex systems, components, and nuclear work facilities at the Naval Nuclear Propulsion Program project sites that BMPC manages. BWSR operates at the Naval Reactors Facility in Idaho, the Bettis Laboratory in Pennsylvania, and the Knolls Laboratory and the Kesselring Site in New York. Activities include the complete demolition of inactive facilities, as well as the removal of complex systems in operating nuclear facilities, to allow for new systems installations.

Westinghouse Electric Company announced on Sept. 27, 2017, that is has signed a contract with Jadrová a vyraďovacia spoločnosť (JAVYS) for the dismantling of the reactor coolant systems of two VVER-440 units at the Bohunice V1 nuclear power plant (Bohunice-1 and -2, which were permanently shut down in 2006 and 2008, respectively) in Slovakia. The European Bank for Reconstruction and Development is financing the project. The scope of the contract covers the decontamination, dismantling, and fragmentation of power reactor pressure vessels, power reactor internal components, and other power reactor structures, systems, and components of Bohunice V1. It also includes material and waste management in accordance with Slovak and European Union regulations.

On Oct. 10, 2017, **Jacobs Engineering Group** announced that it has been awarded a four-year framework agreement from Dounreay Site Restoration Limited (DSRL) to provide mechanical, electrical, and instrumentation and controls services for the Dounreay site in Caithness County, Scotland. According to Jacobs, the Dounreay site is one of Europe's most complex nuclear cleanup projects and is a hub of nuclear decommissioning innovation, with extensive remediation activities under way to return the site to as near its original condition as possible. Jacobs said that it has delivered professional design, engineering, safety, environmental, planning, and management services to DSRL for 22 years.

On Oct. 16, 2017, **Orano** (formerly Areva) announced that within the scope of the dismantling of the Philippsburg-2 and Neckar-2 nuclear power plants, its **Areva Decommissioning and Services GmbH-EWN** consortium has been selected by Germany's EnBW to dismantle the reactor pressure vessel internals and segment and package them, along with other reactor core waste. According to Orano, the operation will be carried out mainly underwater using tried and tested dismantling technology, including specific remote-operated underwater equipment. The contract follows the collaboration between Orano and EnBW, and enhances the consortium's position within the German dismantling market, Orano said. Philippsburg-2 and Neckar-2 are scheduled to shut down in 2019 and 2022, respectively.

Nuvia, an international nuclear engineering, project management, and services contractor, announced on Nov. 7, 2017, that it has secured a multimillion-dollar contract from Magnox Ltd. in support of the Dragon Reactor decommissioning project at Winfrith in Dorset, England. The decommissioning project will remove the core of the reactor and pack the resulting waste generated into packages for disposal, and forms part of a wider program to decommission the whole of the Winfrith premises. Under the contract, Nuvia will design, manufacture, construct, install, and test a range of mechanical and electrical control and instrumentation systems, including shield doors, ventilation systems, waste packing and export, and radiological assay systems.

Waste management

The private equity firm **Caruth Capital Partners** announced on Nov. 9, 2017, that it has invested growth capital in **Secur LLC**, a small business based near Pittsburgh, Pa., specializing in the packaging, transportation, and disposal of radioactive wastes and by-products. Jennifer Evanko, chief executive officer and chair of Secur, said that Caruth's investment will help accelerate the company's aggressive growth strategy through the development of new packaging products and expansion of the company's transportation container assets, railcars, and service offerings. Secur provides clients in industry and government with asset-based packaging, logistics, and technical services that enable them to handle a range of radioactive, hazardous, industrial, and other complex wastes that are generated from environmental remediation, decommissioning, and waste management activities.

On February 1, **Secur LLC** announced that it has signed an exclusive North American distribution agreement for Slovenia-based **Container d.o.o.'s** ATOM line of intermodal container products for radioactive materials. According to Secur, the ATOM containers give nuclear and radioactive industry shippers enhanced flexibility and significant cost benefits for packaging and transportation programs. The Type A containers are available in 10-, 20-, and 40-foot lengths with optional, removable hard lids for full access to the top and end of the container for loading. Containers are certified for rail, barge, and truck transport as well as for international marine shipping. The containers can be modified with removable headers, shielding, and racking systems.

On Oct. 25, 2017, **Wood** announced that it has won a contract from Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) to recover and package low-level radioactive waste from a storage silo at the Marcoule nuclear site in France. The contract with CEA was won in partnership with **Areva Projets SAS** and covers project management, safety case, detailed design, commissioning, and the first six months of operations. Wood and Areva Projets will work together to retrieve 50 metric tons of waste that has been stored at CEA's Marcoule site for more than 50 years. Wood said that it will design a remotely operated robotic arm to remove the waste elements from the silo and also design a manufacturing unit to encapsulate them for long-term storage.

On Dec. 18, 2017, Orano (formerly Areva) announced that over a period of a few months, the company has signed three contracts totaling nearly €9 million (about $10.8 million) for the treatment and management of radioactive waste at sites belonging to the Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) in Fontenay-aux-Roses and Cadarache. The first of the three contracts is for the treatment of liquid chemical wastes of varying radiological intensity, from very low level to medium activity, at the CEA site in Fontenay-aux-Roses. The treatment consists of neutralizing the different effluents through a series of processes to reduce their radiotoxicity before safe storage. The second contract is a five-year renewal, with possible extensions, of the operating contract for the waste treatment station at the Cadarache site, which Orano's Dismantling and Services business has been operating on behalf of the CEA for several decades. This contract includes the management of the waste packages as well as the general maintenance of the facility. The third contract from the CEA in Cadarache, received in early November 2017, is for the safe maintenance of the former effluent treatment station for a period of 40 months.

On Dec. 18, 2017, **Cavendish Nuclear,** a **Babcock** subsidiary, announced that it has been awarded a £95-million (about $127-million), 10-year contract to supply Sellafield Ltd. with glovebox systems to process nuclear material at the Sellafield nuclear site in Cumbria, England. Along with supplier **Jordan Manufacturing**, Cavendish will design, manufacture, and supply the glovebox systems for future Sellafield plants that will treat and manage nuclear materials. Manufacturing work will be done at Babcock's Rosyth facility in the United Kingdom.

DOE

Alexandria, Va.–based engineering company **MPR** announced on Sept. 12, 2017, that the U.S. Army Corps of Engineers (USACE) awarded the company a $48-million, multiyear contract to provide support services to the Department of Energy and other U.S. government agencies on behalf of the USACE. According to MPR, the agreement enables the company and its subcontractors—Black and Veatch, Project Time & Cost, Nuclear Consultants and Engineers, Neptune and Company, and Sandia Technical Solutions—to continue making contributions similar to those provided on previous USACE contracts. Since 2010, MPR has provided support to the USACE on various projects, including cleanup at Hanford, new construction at Los Alamos National Laboratory, waste processing at the Savannah River Site, cleanup at Oak Ridge National Laboratory, and system modernization at the Waste Isolation Pilot Plant. Under the new contract, MPR will provide a broad range of engineering services, particularly nuclear engineering support for strategic program planning and the independent cost and schedule risk assessment of highly technical, first-of-a-kind construction projects around the DOE complex.

The Department of Energy announced on Sept. 26, 2017, that its Environmental Management Los Alamos Field Office has extended for six months the Los Alamos Legacy Cleanup Bridge Contract with **Los Alamos National Security**, the prime management and operations contractor for the Los Alamos National Laboratory (LANL). The extension, which will expire on March 31, 2018, is valued at approximately $65 million. The contract was originally set to expire on September 30, 2017. The cleanup bridge contract is a cost-plus-award fee contract for environmental remediation services at LANL, including solid waste stabilization and soil and water remediation.

On Dec. 19, 2017, the DOE awarded a five-year, $1.39 billion Los Alamos cleanup contract to the consortium Newport News Nuclear BWXT–Los Alamos (see Headlines, p. 28).

Savannah River EcoManagement (SRE) was awarded a seven-year, $4.7-billion contract from the Department of Energy's Office of Environmental Management for liquid waste services at the DOE's Savannah River Site in South Carolina, it was announced on Oct. 12, 2017. SRE is a joint venture of **BWXT Technical Services Group**, **Bechtel National**, and **Honeywell International**. The liquid waste services include, but are not limited to, the operations of existing radioactive liquid waste facilities for storage, treatment, stabilization, and disposal of waste; waste removal from tanks and tank closures; construction of additional saltstone disposal units; operation of the Salt Waste Processing Facility after facility commissioning, startup, and one year of operation; and liquid waste program and regulatory support.

The DOE's Office of Environmental Management (EM) announced on Oct. 30, 2017, that it has awarded a $4-million, three-year indefinite delivery/indefinite quantity contract to **Ardent Technologies,** of Dayton, Ohio, to provide information technology support services to the EM Consolidated Business Center and various locations across the EM complex. The company will provide full- and part-time services for information systems operations support for IT desktop and server management, network infrastructure services, cybersecurity programs, data facility management, application maintenance support, and associated program elements and project management. Fixed price and time-and-materials–type task orders may be issued against the contract for specific work, the DOE said.

NRC

On Oct. 23, 2017, information technology company **Unisys Corporation** announced that it was awarded a contract to provide services and support to move the Nuclear Regulatory Commission's computing operations to a cloud platform. According to Unisys, by moving its computing operations and applications to the cloud, the NRC will be able to securely and efficiently run critical applications without extensive upfront capital investments in IT resources. Work under the contract will include the implementation of the Unisys solution to move workloads to the cloud, and the subsequent operation and maintenance of the agency's high-performance computing cloud environment. ■

Radwaste SOLUTIONS

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Minimization

Mixed Wastes

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Safety

Sampling

Siting

Soil Processing

Sources

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The Tragedy of Yucca Mountain. By Dade W. Moeller. Sept./Oct. 2010: 52-57.

The Tragedy of Yucca Mountain: Part II. By Dade W. Moeller. Jan.-Apr. 2011: 54-58.

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Decommissioning “The Rock:” A Photo Tour of the Big Rock Point Restoration Project. Sept./Oct. 1999: 60-62.

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What If We Lose Barnwell? By Nancy J. Zacha. July/Aug. 1999: 62-63.

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Vitrification

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Multiple Aspects of Cold Crucible Melting. By Antoine Jouan, Jean-Pierre Moncouyoux, Serge Merlin, and Patrice Roux. Mar. 1996: 77-81.

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Calendar

Meetings of Interest

March

Mar. 18–22 **2018 WM Symposia,** Phoenix, Ariz. Organized by WM Symposia, Inc. Contact: Jaclyn Russell, WM Symposia, Inc., phone 480/557-0263; email jaclyn@wmarizona.org; Web www.wmsym.org.

April

Apr. 5–7 **2018 ANS Student Conference,** Gainesville, Fla. Sponsored by ANS and hosted by the ANS University of Florida Student Section. Contact: Conference cochairs, email chair@ansstudentconference2018.com; Web www.ansstudentconference2018.com/.

Apr. 17–19 **World Nuclear Fuel Cycle,** Madrid, Spain. Organized by the Nuclear Energy Institute and the World Nuclear Association. Contact: Michael Jordan, NEI, phone 202/739-8028; email conferences@nei.org; Web www.nei.org.

Apr. 30–May 3 **2018 CRPA-ACRP Annual Conference,** Québec City, Québec, Canada. Organized by the Canadian Radiation Protection Association (Association Canadienne de Radioprotection). Contact: CRPA-ACRP, phone 613/253-3779; email secretariat@crpa-acrp.ca; Web http://crpa-acrp.org/conference/.

May

May 1–3 **Used Fuel Management Conference,** Savannah, Ga. Sponsored by the Nuclear Energy Institute. Contact: NEI, phone 202/739-8000; email conferences@nei.org; Web www.nei.org.

May 13–18 **18th Radiochemical Conference (RadChem 2018),** Mariánské Lázně, Czech Republic. Organized on behalf of the Division of Nuclear and Radiochemistry of the European Association for Chemical and Molecular Sciences. Contact: RadChem 2018, fax +420 222 320 861; email radchem@fjfi.cvut.cz; Web www.radchem.cz.

May 20–23 **5th Asian and Oceanic Regional Congress on Radiation Protection (AOCRP-5 2018),** Melbourne, Australia. Sponsored by the Australasian Radiation Protection Society. Contact: Paula Leishman, Leishman Associates, phone +61 03 6234 7844; fax +61 03 6234 5958; email paula@laevents.com.au; Web www.aocrp-5.org.

May 20–23 **27th Annual RAPID Technical Conference and Vendor Exhibit,** Clearwater, Fla. Sponsored by Curtiss-Wright. Contact: Rose Kieffer, Curtiss-Wright, phone 727/669-3055; email rkieffer@curtisswright.com; Web www.eiseverywhere.com/ehome/303189.

May 24–25 **9th Annual Nuclear Decommissioning Conference Europe,** Manchester, England. Sponsored by the Nuclear Energy Insider. Contact: Louis Thomas, Nuclear Energy Insider, phone 800/814-3459, ext. 7246; e-mail lthomas@nuclearenergyinsider.com; Web www.nuclearenergyinsider.com/decom.

June

June 2–6 **ASME 2018 Annual Meeting,** San Francisco, Calif. Sponsored by the American Society of Mechanical Engineers. Contact: Kim Williams, ASME, phone 212/591-7037; email williamsk@asme.org; Web www.asme.org.

June 3–6 **38th Annual CNS Conference and 42nd Annual CNS/CNA Student Conference,** Saskatoon, Saskatchewan, Canada. Hosted by the Canadian Nuclear Society. Contact: Benjamin Rouben, CNS, phone 416/977-7620; email annualconference@cns-snc.ca; Web http://cns-snc.ca/events/cns2018/.

June 4–8 **5th European IRPA (International Radiation Protection Association) Congress,** The Hague, Netherlands. Hosted by the Dutch Society for Radiation Protection. Contact: A Solution Events, phone +31 85 90 22 833; email info@irpa2018europe.com; Web http://irpa2018europe.com/.

June 7–8 **Decommissioning Strategy Forum,** Nashville, Tenn. Sponsored by Exchange Monitor Publications & Forums. Contact: Kristy Keller, phone 301/354-1779; email kkeller@exchangemonitor.com; Web www.decommissioningstrategy.com.

June 17–21 **2018 ANS Annual Meeting,** Philadelphia, Pa. Sponsored by the American Nuclear Society. Contact: Krishna Singh, Holtec International, phone 856/797-0900, ext. 3920; email k.singh@holtec.com; Web www.ans.org/meetings/m_244.

June 17–21 **Embedded Topical: Nuclear Fuels and Structural Materials for Next Generation Nuclear Reactors,** Philadelphia, Pa. Sponsored by the ANS Materials Science & Technology Division. Contact: Kurt Terrani, Oak Ridge National Laboratory, phone 865/576-0264; email terranika@ornl.

gov; or Heather MacLean Chichester, Idaho National Laboratory, phone 208/533-7025; email heather.chichester@inl.gov; Web www.ans.org/meetings/m_244.

June 25–28 **Radiological Effluents and Environmental Workshop,** New Orleans, La. Sponsored by the Nuclear Energy Institute. Contact: NEI, phone 202/739-8000; email conferences@nei.org; Web www.nei.org.

July

July 15–19 **HPS 63rd Annual Meeting,** Cleveland, Ohio. Sponsored by the Health Physics Society. Contact: HPS, phone 703/790-1745; email hps@burkinc.com; Web www.hps.org.

July 22–26 **INMM 59th Annual Meeting,** Baltimore, Md. Sponsored by the Institute of Nuclear Materials Management. Contact: INMM, phone 856/380-6813; email inmm@inmm.org; Web www.inmm.org.

July 29–Aug. 1 **U.S. Women in Nuclear Conference,** Huntsville, Ala. Organized by the Nuclear Energy Institute. Contact: NEI, phone 202/739-8000; email conferences@nei.org; Web www.nei.org.

July 29–Aug. 2 **Radiation Protection Forum,** Naples, Fla. Sponsored by the Nuclear Energy Institute. Contact: NEI, phone 202/739-8000; email conferences@nei.org; Web www.nei.org.

September

Sept. 4–6 **RadWaste Summit,** Henderson, Nev. Organized by Radwaste Monitor. Contact: Kristy Keller, ExchangeMonitor Publications & Forums, phone 301/354-1779; e-mail kkeller@exchangemonitor.com; Web www.radwastesummit.com.

Sept. 5–7 **World Nuclear Association Symposium 2018,** London, England. Organized by WNA. Contact: Sharan Gallagher, WNA, phone +44 0 20 7451 1521; e-mail events@world-nuclear.org; Web www.wna-symposium.org.

And coming up (ANS meetings) . . .

2018 ANS Winter Meeting and Nuclear Technology Expo, Nov. 11–15, 2018, Orlando, Fla.

Embedded Topical: 23rd Topical Meeting on the Technology of Fusion Energy (TOFE), Nov. 12–15, 2018, Orlando, Fla.

Embedded Topical: International Topical Meeting on Advances in Thermal Hydraulics—2018, Nov. 11–15, 2018, Orlando, Fla.

2019 ANS Annual Meeting, June 9–13, 2019, Minneapolis, Minn.

2019 ANS Winter Meeting and Nuclear Technology Expo, Nov. 17–21, 2019, Washington, D.C. ■