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DECONTAMINATION OF THE HEAD END CELLS AT THE WEST VALLEY DEMONSTRATION PROJECT

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ABSTRACT

Clean-up efforts at the West Valley Demonstration Project have shifted from their long focus on high-level radioactive waste processing to decontamination and dismantlement (D&D) of the former nuclear fuel reprocessing plant. Initial D&D efforts are being focused on the clean-up of the Head End Cells (HECs). The HECs were originally used to mechanically prepare spent nuclear fuel (SNF) for chemical processing for the recovery of uranium and plutonium. The HECs are heavily shielded hot cells formerly used to shear the SNF, store the sheared SNF prior to chemical dissolution, and receive the leached SNF hulls for eventual transfer to an on-site disposal area.

The HECs contain a significant quantity of loose debris generated during SNF recovery operations and, as a result, are heavily contaminated with spent fuel, activation products, and fission product radionuclides. Radiation levels in the HECs range from general area dose rates of 100 R/hr to hot spots of 2,000 R/hr. Beta/gamma removable contamination levels are on the order of billions of disintegrations per minute. All the clean-up work in the HECs must therefore be performed remotely.

HEC clean-up efforts are further complicated by the need to replace the majority of the remote-handling equipment (e.g., cranes and power manipulators) in areas with limited access and limited space. To date, the HEC project has completed the repair and replacement of this critical facility equipment and has initiated clean-up in one of the hot cells.

The significant challenges associated with decontamination of these highly radioactive and highly contaminated cells, and the lessons learned from initiating clean-up, are applicable to hot cell clean-up work throughout the Department of Energy (DOE) Complex.

BACKGROUND

The West Valley Demonstration Project (WVDP) is located at the site of the former and only commercial spent nuclear fuel reprocessing facility to have operated in the United States. The plant was constructed in 1966 on land owned by the State of New York and operated for six years, reprocessing approximately 700 tons of spent nuclear fuel, and producing about 600,000 gallons of liquid high-level radioactive waste.

In 1980, Congress passed the WVDP Act, authorizing the Department of Energy (DOE) to conduct a nuclear waste management demonstration project at the Western New York Nuclear Services Center (WNYNSC) near West Valley, NY. Since 1982, the DOE and its partners - the New York State Energy Research and Development Authority (NYSERDA) and the prime contractor, West Valley Nuclear Services Co. (WVNSCO) - have demonstrated that the high-level waste (HLW) can be safely and successfully placed into a vitrified waste form that provides long-term stability in the environment. Since 1996, the WVDP has produced 258 canisters of vitrified HLW glass. These are currently being stored in an on-site facility until a federal repository is available to receive the waste.

The WVDP has now turned its focus to decontaminating portions of the facility that were used during spent fuel reprocessing operations. The first facilities to be decontaminated will be the ones containing the greatest amounts of long-lived radionuclides; these are referred to as the Head End Cells (HECs). Decontaminating these facilities includes the repair and replacement of failed equipment, and retrieving, characterizing, processing, packaging, and storing loose debris.

DESCRIPTION OF THE HEAD END CELLS

The HECs were used to mechanically prepare and handle irradiated nuclear fuel assemblies. The HECs includes eight cells and rooms, with the two principal facilities being the Process Mechanical Cell (PMC) and the General Purpose Cell (GPC).

The PMC is 12 feet wide, 52 feet long, and 25 feet high. The concrete walls and floor of the PMC are 5.5 feet thick and the ceiling is 6 feet thick. The floor is covered with 304L stainless steel, which also extends up the walls to a height of 20.67 feet. The walls above the stainless steel are coated with a carboline-based paint. The GPC is similarly constructed, with its dimensions approximately 10 feet wide, 45 feet long, and 19 feet high.

During former reprocessing operations, the PMC was used to mechanically size-reduce spent nuclear fuel, separating the fuel assemblies from the spent fuel and shearing the fuel into 0.50 to 2.0 inch lengths. The sheared fuel was stored in the GPC until it was transferred to the Chemical Process Cell (CPC) for chemical dissolution. After dissolution, the leached fuel hulls were returned to the GPC, and then packaged and transferred to an on-site waste disposal area. Some of the leached hulls were transferred from the GPC through the PMC to the Analytical Labs where the effectiveness of the dissolution process was assessed. After the hulls were examined in the Analytical Labs, they were also returned to the GPC for packaging and disposal.

Major equipment in the PMC and GPC includes bridge cranes and bridge-mounted power manipulators, wall-mounted manipulators, a cut-off saw, a fuel shear, and a fuel basket handling unit. Much of the equipment has failed or has not been operated for many years.

A significant amount of loose debris remains in the PMC and GPC. The debris consists of general contaminated equipment and scrap from fuel and waste handling, fuel assembly hardware, leached fuel hulls, fine particles, and potentially some miscellaneous fuel-bearing objects. In the mid-1980s, waste from the Analytical Cells was placed in the PMC. Water had infiltrated the GPC due to its below-grade location, although recent videos indicate that no water remains in the cell. In addition, three canisters containing fine debris vacuumed from the floor of the adjoining CPC during that cell's decontamination are in storage in the GPC.

The PMC and GPC are highly contaminated with spent fuel, activation products, and fission product radionuclides. Radiation levels in the cells vary from a general field of 100 to 300 R/hr six feet from the floor, to up to 2,000 R/hr in localized hot spots. Removable contamination levels are on the order of billions of disintegrations per minute (dpm). In addition, the laboratory waste in the PMC may contain hazardous constituents.

DECONTAMINATION CHALLENGES

The primary consideration for cleaning up the HECs is ensuring the radiological protection of workers and the environment. The WVDP's policy is to maintain radiation exposure of workers as low as reasonably achievable, (ALARA). The most effective way to achieve this goal is to perform operations remotely. Unfortunately in the case of the HECs, much of the remote operations equipment had deteriorated to an unusable condition, including the shielded viewing windows, the GPC shield door that shielded an adjacent Crane Maintenance Room, and all the remote handling capabilities. Replacement and repair of the equipment was necessary before debris retrieval and packaging could begin.

In parallel with these physical facility changes, the safety and waste management bases for performing the expected work activities were reviewed and new approaches developed. Again, the chief consideration was radiological; evaluating the criticality potential of the spent fuel-related debris and arriving at the most effective and efficient way to collect and package it.

The Head End Cells Project team was formed to ensure integration between the various aspects of the project. The core team consisted of a project manager and various project leads. Each of the project leads was assigned an area of specific responsibility. To aid the project leads, support personnel were matrixed into the project. The support personnel included, Radiation Protection, D&D Operations, Waste Management, Design Engineering, Industrial Health and Safety, Procurement Services, Project Controls, Construction Projects, and Quality Assurance.

Shield Window Refurbishment

All the shielded viewing windows in the PMC and GPC had deteriorated to the point where they no longer provided visual access to the cells. Each of the shield window assemblies consists of leaded shield glass in a concrete/cast iron shot-filled window assembly. The spaces between the shield glass panes are filled with mineral oil. In the PMC, the total window assembly weighs approximately 15 tons, with each piece of shield glass weighing between 800 to 1,500 lbs. The windows needed to be pulled from the window cavity into the operating aisle to allow for removal and replacement of the glass and fluid, but the floor in the operating aisle could not support the weight of the window assembly. To help distribute the 15-ton weight of the window assembly and to facilitate its removal, a structural steel extraction table was installed in the aisle. To protect the workers and control the spread of contamination during the removal process, a containment tent was erected in the operating aisle within which all the refurbishment work took place. Airborne radioactive contamination was managed by ventilating the containment tent back to the PMC through an empty manipulator port, thereby eliminating the potential for releasing radioactive contamination from a local filtration system failure. Radiation exposure to personnel was reduced by installing temporary steel shielding around the window opening while a temporary shield door was slid into place in front of the window cavity. Lessons learned from refurbishment of the first windows were incorporated by the project team into the field work for subsequent windows, resulting in a reduction of the time needed for refurbishment of the later windows by almost 75%. These radiological protection measures allowed personnel to perform the refurbishment work in radiation fields of less than 5 mR/hr and resulted in no personnel contaminations.

Fig. 1. Shield Window Refurbishment

GPC Shield Door Repair

The GPC shield door required repair to allow personnel entry in the GPC Crane Room (GCR) to support removal of failed equipment. The 50-ton shield door had been left in a halfway open position and the drive mechanism located in the GCR had failed. The drive mechanism was damaged further from periodic flooding of the GCR from surface water infiltration. General area dose rates in the GCR were 30 to 150 mR/hr, with hot spots greater than 300 mR/hr gamma. There was also a large amount of dirt and debris covering the floor. Removable contamination levels exceeded 1M dpm beta/gamma. An engineering evaluation was performed, with significant input from Radiation Protection and Maintenance personnel. It was determined that replacement of the failed components, rather than a new design and equipment fabrication, would best ensure the maximum degree of radiological protection and cost effectiveness. A means to safely secure the shield door during the repair process was also devised using standard trailer jacks and a base plate grouted to the floor. Due to the complexity of the repair work, the project team decided to construct a full-scale mockup of the GCR. This full-scale mockup then allowed Operations and Maintenance personnel to review each step of the repair process and develop the necessary tools and techniques to accomplish the repair. Prior to the repair work being started, one-half-inch thick steel shield plates were placed on the floor of the GCR to cover the contaminated dirt and debris. General area exposure rates were reduced by more than 20% and airborne contamination levels were reduced by 99%. The drive mechanism replacement was then conducted over a four-month period. The refinement and execution of the repair approach resulted in a personnel exposure reduction of greater than 65% from the original 2,980 person millirem estimate to 1,037 person millirem. A contamination fixative was also applied to the old equipment to ensure that airborne contamination levels remained low and to facilitate its future packaging for disposal.


Fig. 2. GCR Shield Door Repair

Remote-Handling Equipment Replacement

Removal of the failed bridge-mounted cranes and power manipulators posed a significant contamination control challenge. New hard-walled enclosures were constructed over the existing PMC Crane Room (PMCR) and GCR to serve as buffer areas during removal and replacement of the crane bridges. Concrete roof hatches weighing up to 25 tons were removed or relocated from the ceiling of each crane room to provide ready access to the cranes during the removal process, and lighter steel covers were installed in their place.

The crane bridges were constructed of carbon steel and measured 16 feet rail-to-rail and were 9 feet wide; each weighed approximately 7 tons. Initial radiological data on the crane bridges showed high contamination levels and dose rates of 30 to 80 mR/hr, with hot spots of up to 650 mR/hr. The initial dose estimate, based on hands-on mechanical size-reduction, was 1,600 person millirem. Due to the high potential personnel exposure, the project team conducted an evaluation of


Fig. 3. Oxy-gasoline Cutting of PMC Crane Bridges

alternative cutting methods. An oxy-gasoline cutting technology was found through a technology sharing program with the Fernald Environmental Management Project. The oxy-gasoline technology offered the advantages of cutting much faster and providing several safety features not found with oxy-acetylene torch cutting. Working directly with the torch vendor, a first-of-its-kind, 13-foot-long cutting tool was fabricated. This specially designed torch allowed operations personnel to size-reduce the PMC crane bridges while standing in the enclosure located above the PMCR.

Before using the oxy-gasoline torch, a full-scale mock-up of the bridge girder was fabricated and constructed. The mockup provided a means to train Operations personnel in the use of the torch and refine the tools and techniques to be used. As an added measure to control the spread of contamination during cutting, a strippable coating was sprayed on the bridges and other miscellaneous pieces of equipment. The entire evolution, from set-up to crane bridge removal, lasted seven weeks for the first of two PMC crane bridges. The project team reviewed the work done on the first crane bridge and implemented improvements for removal of the second bridge. By factoring in the lessons learned, the time to complete the removal of the second crane bridge was reduced to two weeks.

The new single bridge, having both the crane and the power manipulator, was then installed through the PMCR enclosure onto the rails in the PMCR. The bridge was moved into the PMC and successfully tested.

Because the GPC crane bridge was of lighter construction and due to the airborne hazards associated with thermal cutting, mechanical cutting was used instead. The crane bridge and power manipulator bridge were moved to the GCR. Personnel entered the room and performed hands-on, size-reduction of the bridges using a special large-capacity band saw. Similar to work done in the PMC, the new GPC crane bridge was installed through the GCR enclosure onto the crane rails in the GCR, moved into the GPC, and successfully tested.

Safety Basis

The Safety Analysis Reports (SARs) written by WVNSCO and the accompanying Safety Evaluation Reports (SERs) written by the Nuclear Regulatory Commission (NRC) and DOE serve as the safety basis for the WVDP. The applicable SAR was reviewed at the early stages of project planning and it was determined that a revision was necessary. The primary reason for a revision was an existing NRC SER restriction prohibiting disturbance of the material in the GPC prior to obtaining complete characterization information. This restriction had come about based on previous criticality evaluations, which considered the presence of water in the GPC, and concluded that under certain conservative conditions, a criticality event was credible if the spent fuel-related debris was reconfigured. To address the NRC SER restriction, additional process knowledge characterization information was documented and criticality safety analyses were prepared based on the planned GPC work. These analyses considered the proposed methods for collecting and packaging the spent fuel-related debris. Lifting the restriction was justified by showing that both under normal and under credible abnormal and accident conditions the areas being cleaned and the storage areas would remain subcritical. The analyses were then transmitted to the NRC for review and concurrence along with a proposed revision to the SAR. The NRC has concurred with the new SAR and has issued a SER that lifts the prohibition on disturbing the material in the GPC. To go along with the issuance of a revised SAR, the procedures that implement the SAR requirements in the field have been prepared and will be issued concurrently. By considering the field implementation of the safety requirements early on while preparing the criticality analyses, maximum field flexibility has been built in to the safety basis.

The original strategy for revising the SAR was to consider clean-up of the HECs as a single effort. However, as a single effort, work in both cells could not proceed until the lengthy SAR revision and approval process was completed and the NRC SER restriction lifted. Therefore, to accelerate clean-up, the facility infrastructure upgrades were re-evaluated and approved to proceed in parallel with the SAR revision. Also, since the NRC SER restriction applied only to the GPC, the PMC work was separated from the overall HEC's work scope. The planned PMC work was then evaluated on its own and it was determined to be within the existing safety basis. PMC clean-up work was accelerated by two years using this approach.

A fire hazards analysis (FHA) was also conducted for proposed HECs operations. The presence of combustible material and potentially pyrophoric metal (zircaloy fuel cladding) in the cells was evaluated in terms of the likelihood and consequence of fires occurring. Fire protection measures were then devised based on the recommendations in the FHA, including packaging combustible material first in the debris retrieval sequence, restricting and controlling the use of "thermal" methods of debris size-reduction, and prohibiting the use of decontamination methods that would remove the oxide layer present on zircaloy fuel cladding. The physical facilities were also modified for fire protection purposes. A screen was placed over the open hatch between the PMC and the GPC to reduce the amount of particulate sent downstream to the ventilation system filters during a fire. That screen also reduces the amount of airborne particulate sent to the filters during normal operations. A similar screen may be installed over the ventilation outlet in the GPC. A supply of Class D fire extinguishing agent was placed in the PMC for delivery by the remote-handling equipment to provide fire response capabilities in case of a metal fire. The same material will also be placed in the GPC prior to starting clean-up there.

Waste Management Basis

In addition to the characterization and packaging issues for highly radioactive waste common throughout the DOE Complex, the WVDP also has some unique problems of its own. The former spent fuel reprocessing activities at the WNYNSC were considered a commercial operation and therefore the WVDP was not included as a defense-related facility in the legislation that created the Waste Isolation Pilot Plant (WIPP). As such, the WVDP's transuranic (TRU) waste cannot be shipped to WIPP for disposal. However, in the absence of any other disposal facility for TRU waste and recognizing that most, if not all, the debris to be packaged in the HECs would likely be categorized as TRU waste, waste packaging plans were developed using WIPP's established contact-handled (CH) and proposed remote-handled (RH) TRU waste acceptance criteria (WAC).

There are two key factors for planning to satisfy the WIPP WAC during D&D operations: having information on the chemical, physical, and radiological composition of the debris; and using containers that either meet the WAC, or containers that can later be placed into WIPP-acceptable disposal containers. However, the characterization information existing prior to clean-up was limited; only in-cell radiation measurements and partial radiological analysis from 1986 were available. Therefore, a sequential characterization approach was taken. The debris types in the HECs were evaluated based on their origin for their potential radiological composition and their likelihood to contain hazardous constituents. Sampling and analysis plans were developed to gather further characterization information on each identified waste type. A process knowledge-oriented approach was then used to develop preliminary waste stream classifications to allow packaging activities to start in the PMC. This approach would provide composition information on the waste streams to be packaged, not on the specific debris items in any individual container. Individual container characterization for WIPP acceptance and transport classification would be performed later when the containers were placed in their final disposal container. An innovative in situ gamma spectroscopy unit has been procured for deployment within the HECs. This unit will aid in identifying and quantifying gamma-emitting radionuclides in debris and equipment, and for targeting specific areas for sampling. Field characterization activities were conducted first in the PMC. Lessons learned from PMC sampling and analysis activities will be incorporated into the GPC characterization campaign to be conducted starting in the spring of 2002.

Thirty-gallon containers were selected for packaging debris based on the size constraints of the HECs and to allow for the greatest degree of flexibility for packaging into the final disposal container. The hatches between the hot cells had all been sized to accommodate the transfer of 30-gallon containers. The 30-gallon containers selected are essentially the same as the scrap drums used during spent fuel reprocessing operations. The 30-gallon container also offers more options for overpacking and shielding than are available with larger containers. For example, the 30-gallon container can be placed readily into the proposed RH-TRU waste canister from a sizing standpoint, whereas the exterior diameter of a 55-gallon drum and the RH-TRU canister’s interior diameter are essentially the same dimension, possibly making for operational difficulties during remote packaging.

Start-Up

In parallel with these major equipment and program activities, a myriad of other tasks were completed prior to operations including providing specific tools for remote operations, ensuring essential spare equipment was in place and repair capabilities existed, ensuring field implementing procedures were available, and training and qualifying both operations and support personnel to perform the clean-up work.

Once WVNSCO deemed itself ready to undertake the start of clean-up in the PMC, a Readiness Assessment (RA) was performed to confirm operational readiness. The RA was conducted over a two-month period from June 2001 to August 2001 and validated WVNSCO's preparations. Clean-up operations were initiated in the PMC on August 30, 2001. From September 2001 to December 2001 nine 30-gallon containers of contaminated equipment and scrap have been retrieved and packaged for storage. Retrieval of contaminated equipment and scrap, fuel assembly hardware, and laboratory waste in the PMC is expected to continue through the remainder of fiscal year (FY) 2002, with vacuuming the fine particles and retrieval of leached fuel hulls and miscellaneous fuel-bearing objects expected to begin in FY 2003.

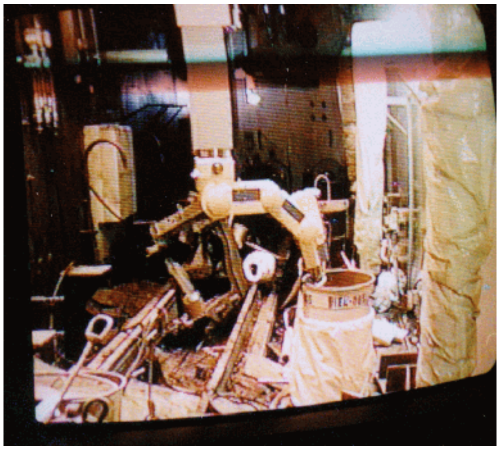
Fig. 4. Packaging in PMC

Similar preparations are underway to initiate clean-up in the GPC. A readiness evaluation is currently scheduled for the 3rd quarter of FY 2002, with clean-up to start immediately afterwards.

CONCLUSION

The initiation of D&D activities in the highly radioactive hot cells at the WVDP has posed significant engineering and operational challenges. The prime success factor was planning and implementing the field work as a project team. At the outset, team members from all the involved organizations were assigned to provide dedicated support to the project. These same people stayed with the project from design to fabrication to installation and testing through to operation, including the key line departments: D&D Operations, Radiation Protection, and Maintenance. At each stage, the completed work was reviewed with a critical eye towards finding areas for improvement. With the PMC and GPC clean-up schedules staggered, the lessons learned from start-up of the PMC can be applied directly to the GPC.