Decommissioning Lessons Learned

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HISTORICAL SITE ASSESSMENTS

The Historical Site Assessment (HSA) is the first step in the Radiation Survey and Site Investigation Process and is a detailed investigation to collect existing information for the site and its surroundings. The following are some of the most important lessons learned from utility experience with historical site assessments.

- The scope of the HSA is broad and should be designed to provide an in-depth assessment of the operating impact on site in terms of site contamination. One of the most important tasks of the HSA is the identification of potential, likely, or known sources of radioactive material, radioactive contamination, or chemical contaminations based on existing or derived information. Some other tasks include the identification of sites that may pose a threat to human health and ecologically sensitive habitats, an assessment of the likelihood of contaminant migration, and the identification of any permits that may require modification during the decommissioning process.
- HSA has major impacts on the planning and scheduling of all subsequent survey activities including scoping surveys, site characterization, site remediation, and the final status survey. Therefore, plants should ensure that adequate time and resources are available to perform an effective HSA. Several decommissioning projects have taken up to 2 years in preparing this document.
- Utilities have found that it is prudent to develop a robust and comprehensive record keeping system and database throughout plant operating life. Such a system will be invaluable in developing the HSA and later in site characterization efforts.
- The accurate pre-characterization of hazardous non-radiological materials such as asbestos, lead, PCBs, and hydrocarbons is equally important as radiological concerns. Hazardous material remediation requires additional work controls, special material handling and packaging and special training for workers.
- There is a wide variety of records on-site that should be used to help document on-site activities and past operations. Analysis of historic information should take special note of processing and storage locations. Special attention should be given to locations identified as sites of waste disposal activities. To the extent possible, sources such as site photographs and aerial surveys should be used to verify the accuracy of records or indicate undocumented changes to site surveys and site drawings.
- Individuals in key record-making departments should be included in the HSA records review since they will be familiar with the history of records turnover for long term storage and can often expedite records searches by knowing the process by which the records may have been indexed historically.

- Personnel questionnaires and interviews have proven to be a valuable source of first-hand information about the site and are useful to verify or clarify information gathered from existing records. The purpose of interviews or questionnaires should be to obtain tacit knowledge of plant operations. In order to assure the needed information is gathered, HSA projects should consider means to allow confidentiality to plant employees since they may feel reluctant to document or discuss perceived negative plant events.
- There are many efforts that operating facilities should make to simplify the development of an HSA after final shutdown. These efforts should include good recordkeeping on radiological and non-radiological spills and soil movement during plant modifications. A series of site aerial photos and pictures of structures, systems and components over time can also simplify the HSA.

Related EPRI Technical Reports

- Capturing Historical Knowledge for Decommissioning of Nuclear Power Plants: Summary of Historical Site Assessments at Eight Decommissioning Plants, EPRI, Palo Alto, CA: 2004. 1009410.
- Decommissioning Pre-Planning Manual, EPRI, Palo Alto, CA: 2001. 1003025.
- Interim Report on Cumulative Risk Assessment for Radiological and Chemical Constituents of Concern at Decommissioning Sites. EPRI, Palo Alto, CA: 2005. 1011735.

2
GROUNDWATER MONITORING PROGRAMS

Recent experience has shown that establishing an effective nuclear power plant groundwater characterization program can require a significant dedication of resources to demonstrate regulatory compliance. The following are some of the most important lessons learned from groundwater monitoring programs during plant decommissioning.

- Several decommissioning nuclear plants have identified the release of small quantities of radionuclides, as well as non-radiological contaminants, during the plant's operating life. In some cases, this leakage has resulted in low levels of contamination in the site groundwater. Final license termination and release of the site property involves demonstrating compliance with the requirements of multiple state and federal regulatory agencies responsible for public health and safety. Quantifying the impact of groundwater contamination in terms of radiation exposure or chemical intake can be a very complex and challenge task. Such investigation demands an expertise in groundwater hydrogeology, a degree of familiarity with nuclear plant operation, and an understanding of the significance of the types and concentrations of radionuclides that may be released to the environment from the plant site.
- Plant managers should engage all stakeholders early and continually throughout the planning and implementation of the groundwater monitoring programs to ensure their understanding and acceptance of its findings. The details of the local hydrogeologic features that control contaminant migration must be sufficiently described and understood to demonstrate to stakeholders that the nature and extent of all release to the groundwater flow domain have been adequately investigated.
- Investigation and monitoring of releases to groundwater should begin early to avoid delays in achieving objectives for license termination and final site release. The program should begin with a thorough review of the operating history of the site, with an emphasis on understanding what releases of contaminants to the environment are know to have occurred. This analysis should identify all actual and potential release mechanisms and the specific areas where they may have occurred. Spent fuel pools, outside water storage tanks, and underground piping are obvious potential sources of groundwater impacts that have been seen at several nuclear power stations.
- Experience to date shows that under leaking conditions, tritium is by far the most mobile and pervasive radionuclide within the groundwater flow domain. The other primary radionuclides of concern to groundwater monitoring are Sr-90, Co-60, and Cs-137.
- Plants should use established investigative techniques, such as EPRI's Groundwater Monitoring Guidance, in developing a technically sound monitoring program. This program should be science-based with defensible data that can be relied upon in developing an understanding of the hydrogeologic systems that control transport of contaminants at a site.

The use of such techniques will help demonstrate an accepted standard of care and enhance the level of acceptance of the resulting work.

- Groundwater investigations are best undertaken with an iterative approach that can be expected to require a minimum to three years to complete, in even relatively simple situations. Full characterization of a site of average complexity will likely require more than three years. Early development of a comprehensive conceptual site model will guide the investigation, focus it in areas requiring the most scrutiny, and reduce the time required for all stakeholders to achieve consensus on the results.
- Monitoring wells are the primary tool used to investigate groundwater contamination. They should be drilled in those locations and depths dictated by an understanding of the site, arrived at by development of a conceptual site model. Stratigraphic variations within a groundwater flow regime exert a controlling effect on the pattern of contaminant transport. Therefore, it is important to thoroughly characterize the stratigraphy of a site at which a release of contaminates to the environment has occurred. Such an effort should include investigating the full depth of the geologic section through which local groundwater flow is likely to extend.
- Numerical modeling of groundwater systems can be a useful tool for predicting future contaminant distributions, for testing hypotheses about the interaction of the hydrologic parameters that influence the flow regime, and for conducting sensitivity analysis of those groundwater parameters. However, modeling may not be practical based on the complexity of the site and the project objectives. Because of the technical and highly specialized nature of numerical modeling, this activity should be undertaken only by highly experienced and qualified professionals.
- Because of the importance of groundwater analytical data in making decision regarding the need for further investigation, groundwater monitoring, or remedial action, a robust program of quality assurance and quality control should be implemented to assess and enhance the reliability and validity of field and laboratory measurements conducted to support these programs.
- If the removal of contaminated soil or other sources of impact to groundwater is required, monitoring may continue for at least one to three years following source removal. Only after contaminant concentrations reach equilibrium throughout the flow domain can a reasoned judgment be made regarding the effectiveness of the remedial action.

Related EPRI Technical Reports

- Groundwater Monitoring Guidance for Nuclear Power Plants, EPRI, Palo Alto, CA: 2005. 1011730.
- Proceedings: 2005 EPRI Topical Workshop – Groundwater Contamination Assessment and License Termination Activities, EPRI, Palo Alto, CA: 2006. 1013166

3
REACTOR COOLANT SYSTEM CHEMICAL DECONTAMINATION

In the U.S., four retired plants used chemical decontamination prior to decommissioning work – Big Rock Point, Maine Yankee, Connecticut Yankee, and Trojan. The following are some of the most important lessons learned from experience at these plants.

- High flow rates yield better results. Operation of the reactor coolant pumps (RCPs) is recommended. Secondary pumps, such as residual heat removal pumps, should be used if the RCPs are not available. Vendor-supplied pumps are the least preferable option since they will have smaller flow capacity than pumps at the site. The benefits of higher flow rates (~2000 gpm) include fewer cycles to achieve higher and more uniform decontamination factors, less deposit of residual chemicals in deadlegs, and less waste.
- It is important to start decommissioning and decontamination planning well in advance of the final plant shutdown. Ideally, the decontamination should be performed immediately after the final plant shutdown while all the plant systems are still well maintained and operational and while knowledgeable plant operations personnel are still available.
- All decontamination processes tend to leave residual chemicals and undissolved particulates in deadlegs and low flow areas. While high flow rates will alleviate this problem somewhat, some collection in deadlegs should be expected. Potential deadlegs should be identified and plants should develop plans to flush them.
- An assembly should be used to bypass the reactor pressure vessel (RPV) during chemical decontamination. It is an excellent way to avoid decontaminating the RPV, which would yield no net benefit to the plant and would only increase the volume of waste produced. Such an assembly should be insulated to improve performance by preventing excessive heat loss to the RPV.
- For PWRs, inclusion of the steam generators (SGs) in the flowpath should be seriously considered. To achieve flow to all the tubes would require operation of the RCPs. While the decontamination of the SGs would yield little immediate benefit in terms of dose savings, it would facilitate disposal of the SGs later on. It is possible that with chemical decontamination, the radiation fields could be sufficiently low that they could be sent to a recycle center for further decontamination and eventually unrestricted release as scrap. The major downside of including the SGs in the flowpath is the additional waste. Each plant must consider SG leakage to determine if decontamination is feasible.
- Flexibility is desirable to quickly address unexpected results. In particular, extra chemical supplies should be available in case addition applications are required to achieve the desired decontamination factor.

- Use of a remote monitoring system with video cameras and dosimeters is very useful in helping to monitor the process while saving personnel exposure. Care should be taken to place the dosimeters away from background sources and deadlegs where chemical residues might settle.
- If the plant has high transuranic activity in the oxide film, resin loading will need to be monitored very closely to ensure acceptability of the waste activity for disposal.

Related EPRI Technical Reports

- Decontamination Handbook, EPRI, Palo Alto, CA: July 1999. 112352.
- Evaluation of Decontamination of the Reactor Coolant Systems at Maine Yankee and Connecticut Yankee, EPRI, Palo Alto, CA: 1999. 112092.
- The EPRI DFDX Process – Final Report: A Process for the Chemical Decontamination of Nuclear Systems and Components for Disposal or Refurbishment. EPRI, Palo Alto, CA: 2006. 1013280.
- Decontamination of Reactor Systems and Contaminated Components for Disposal or Refurbishment: Developments and Experience with the EPRI DFD Chemical Decontamination Process, EPRI, Palo Alto, CA: 2001. 1003026.

4
REACTOR PRESSURE VESSEL INTERNALS SEGMENTATION

One of the most challenging tasks during plant decommissioning is the removal of highly radioactive internal components from the reactor pressure vessel (RPV). These components must be removed to meet established state and federal disposal criteria. The following are some of the most important lessons learned from experiences in RPV internal segmentation.

- Extensive predeployment planning, simulation, and testing should be done prior to any on-site segmentation work. Experience has clearly shown the benefits of comprehensive testing involving a full mockup of the cutting arrangement, materials, tooling, and waste capture and processing system. Computer simulations, such as 3-dimensional CAD-CAM models, can help to identify and mitigate high risk factors in advance.
- In the planning of RPV internal segmentation, plants should commit to capture the lessons learned from preceding projects. The success of one recent project was made possible, in large part, due to a comprehensive list of critical issues derived from numerous visits to other facilities and meetings with experienced project personnel and vendor representatives. These efforts allowed planners to gain first hand knowledge of the work and experience.
- Most recent RPV internal segmentation projects have used abrasive water jet cutting, which provides a reasonable cutting speed and a high degree of precision. In order to achieve the required cutting precision, the mast supporting the cutting head must be rigid and positioned properly.
- Although the use of plasma underwater cutting technology is now sufficiently well tested, it can be a major challenge to collect and process small highly radioactive particles and gases produced from the plasma arc process. Collection of these waste products can be particularly difficult for highly irradiated components. It is therefore imperative that the waste collection system for plasma arc cutting be demonstrated satisfactorily before committing it to a project.
- One of the most difficult challenges in the entire segmentation process is maintaining water clarity through the removal of debris created in the cutting process. Colloidal suspension from the fragmentation of garnet can also present a major challenge. In order to maintain water clarity, it is important to segment the pool cutting area and focus waste collection on this zone. In addition, the processing capacity and the reliability and maintenance of the filtration system are essential to project success. One plant found during initial testing that a simple filtration system quickly clogged and moved to a specially designed and patented filtration system.
- The complete filtration skid should be fully tested prior to bringing it on site. The filtration skid should be designed for underwater operation and the design of all the active components

should allow replacement or repair from the surface, without removing the skid from the cavity pool.

- The amount of cutting should be optimized with respect to the number of cuts and the size of the final waste packages. The cutting plan should minimize the number of cuts, produce waste pieces that can be easily packaged, and minimize the final waste volume. Recent RPV internal segmentation projects have used large spent fuel canisters to store Greater than Class C (GTCC) waste.
- Segmentation should begin with the least irradiated components in order to gain experience with the tooling before applying it to highly radioactive components, where tooling failure could significantly increase personnel exposure.
- In cases where the entire RPV package can be considered non-GTCC waste, intact disposal presents the advantages of less waste volume, less personnel exposure, fewer radioactive shipments, and lower cost. However, current U.S. regulation makes intact disposal unlikely due to the existing requirements associated with the high level of waste activity in RPVs. However, it may be possible to remove the most radioactive internal components and ship the RPV containing a portion of the segmented internals as a package to a low-level radioactive waste disposal facility.

Related EPRI Technical Reports

- Decommissioning: Reactor Pressure Vessel Internals Segmentation, EPRI, Palo Alto, CA: 2001. 1003029.
- Decommissioning San Onofre Nuclear Generating Station Unit 1 (SONGS-1): Reactor Vessel Internals Segmentation, EPRI, Palo Alto, CA: 2005. 1011733
- Trojan Nuclear Power Plant Reactor Vessel and Internals Removal, EPRI, Palo Alto, CA: 2000. 1000920.
- Maine Yankee Decommissioning – Experience Report: Detailed Experiences 1997 – 2005, EPRI, Palo Alto, CA: 2005. 1011734.
- Connecticut Yankee Decommissioning Experience Report: Detailed Experiences 1996 – 2006, EPRI, Palo Alto, CA: 2006. 1013511

5
REMEDIATION OF EMBEDDED PIPING

Characterization, decontamination, survey, and removal of contaminated embedded piping can have a substantial financial impact on decommissioning projects. Most decommissioning plants include several miles of contaminated piping, a substantial portion of which can be embedded within the walls and floors of the plant structure. The following are some of the most important lessons learned from plant experiences with the remediation of embedded piping.

- The success of an embedded piping remediation project (EPRP) depends largely on advance planning, careful consideration and selection of the remediation methods, integration of the project with other decommissioning activities and regulatory approval of the proposed contamination acceptance criteria.
- If embedded piping is to remain following decommissioning, the plant should perform an on-site radiological characterization study to support development of a dose model for remaining embedded piping.
- The most important planning decision for embedded piping remediation is the selection of which method or methods will be used to remove piping contamination. Several remediation options to consider include hyrolasing, media blasting, chemical decontamination, and removal of piping. One plant selected media blasting as its primary method after careful consideration based on high contamination in stainless steel piping with relatively little debris. Each plant should select remediation methods based the envisioned end state for the plant structures (i.e. removal of all structures or partial removal) and industry experience.
- Plants should expect that different remediation methods can be used in different areas. At one plant where media blasting was the primary remediation method, hydrolasing was used where appropriate and piping was removed where it was cost-effective or where hotspots could not be sufficiently cleaned.
- The selection of blast media will likely include a combination of different grit types and sizes. Initial cleaning with aluminum oxide or garnet should be followed by remedial cleaning with the more aggressive grit materials such as silicon carbide.
- Blockages and debris in piping can inhibit the use of some remediation methods and provide locations for contamination to collect in hotspots. Mechanical removal may be needed and video equipment should be used to inspect the pipe interior after removal of surface contamination.
- Efforts should be made to incorporate the equipment and procedures of an EPRP into the plant's quality assurance program as early in the project as possible. This early start is critical to ensure that cleaning activities are not delayed awaiting approval of the survey equipment.

- EPRP activities can be done in parallel with other decommissioning efforts such as equipment removal and surface decontamination activities. However, advance planning should include efforts to minimize conflicts and inefficient use of resources to allow more equipment runtime and flexibility in scheduling.
- Cleaning and survey of piping can be significantly less expensive than embedded pipe removal if the final site survey at a decommissioning plant is to be made with the buildings mostly intact. If demolition is planned, it would likely be less expensive to dispose of it in conjunction with building demolition activities.

Related EPRI Technical Reports

- Remediation of Embedded Piping Trojan Nuclear Plant Decommissioning Experience, EPRI, Palo Alto, CA: 2000. 1000908.
- Embedded Pip Dose Calculation Method, EPRI, Palo Alto, CA: 2000. 1000951.
- Proceedings: Embedded Pipe Decontamination Technology Workshop, EPRI, Palo Alto, CA: 1999. TR-111277.

6
SPENT FUEL STORAGE

After final shutdown, the most significant public health and safety issue at a commercial nuclear power plant relates to storage of spent nuclear fuel. For a significant amount of time after shutdown, spent fuel is stored in the spent fuel pool (SFP) until it can be transferred to an on-site dry storage facility, often called an Independent Spent Fuel Storage Installation (ISFSI). Fuel storage times at each ISFSI are uncertain as decommissioning plants wait for final disposal at a government facility. The following are some of the lessons learned and experiences with SFP cooling and cleanup systems during decommissioning activity.

- Plants should plan to have an operational ISFSI prior to beginning of major decontamination and demolition. Significant time and legal interaction is necessary to secure proper permits for the ISFSI and substantial engineering is required to assure proper spent fuel removal and SFP safety during the remaining operational period prior to decommissioning. The overall decommissioning effort is a much simpler project when fuel is fully out of the pool before the majority of activity begins.
- The majority of nuclear plants currently engaged in decommissioning found significant benefits tied to replacing their original SFP cooling and cleanup system with a unit tailored to shutdown conditions. These decommissioning-specific systems, referred to as nuclear islands, are simpler, smaller, and more localized to the SFP area. This approach significantly reduces the required plant maintenance and monitoring programs. The nuclear island approach also benefits decommissioning by allowing shutdown and removal of major fuel pool support systems such as the SFP purification system, plant service and cooling water systems, extensive plant piping, and major electrical support systems. The shutdown and removal of these components significantly reduces the energy demand required within the plant. Finally, the move to the use of a nuclear island allows decommissioning work to begin in many more areas of the plant.
- The cooling aspect of the nuclear island SFP system is significantly different from those of operating plants. Some plants maintain the local body of water as the ultimate heat sink, while others switch to ambient air. Component redundancy has been employed for some parts of these systems, but not all because they are not generally classified as safety-related based on an engineering evaluation of the SFP cooling requirements. Backup electrical power is a common feature.
- The cleaning aspects of the nuclear island SFP system typically include mixed-bed demineralizers, filters, and pool skimmers. The specific implementation varies among plants as some have adopted a portable high-flow unit and some have maintained portions of their original cleanup system in anticipation of higher cleanup requirements. A few plants have placed components of the cleaning system within the SFP.

- Cesium, cobalt, and tritium are the dominant soluble radionuclide constituents of SFP water after final shutdown. There is typically no technical specification on their allowable concentration. Many plants have specifications for pH and/or conductivity but the presence of a specification and its value varies. It is noteworthy that some plants have increased the requirements for water quality after final shutdown beyond those used during power operation.
- Resin usage is low at most plants and changeouts are very infrequent unless a significant pool disturbance occurs. In some cases, the resin change out is made to avoid generation of Class B or C wastes.
- Plants with any history of fuel damage should prepare special contingency plans in case fuel pellets or other damage is found during final fuel inspection.
- Even through shutdown, it is important to maintain good fuel pool chemistry to support fuel handling and transfer options.

Related EPRI Technical Reports

- Spent Fuel Pool Cooling and Cleanup Systems – Experience at Decommissioning Plants, EPRI, Palo Alto, CA: 2002. 1003424.
- Spent Fuel Pool Cooling and Cleanup During Decommissioning: Experience at Trojan Nuclear Power Plant, EPRI, Palo Alto, CA: 1999. TR-112351.
- Trojan Spent Fuel Pool Chemistry Control During Fuel Transfer to Storage Cask, EPRI, Palo Alto, CA: 2001. 1001321.
- Maine Yankee Decommissioning – Experience Report: Detailed Experiences 1997 – 2004, EPRI, Palo Alto, CA: 2005. 1011734.
- Connecticut Yankee Decommissioning Experience Report: Detailed Experiences 1996 – 2006, EPRI, Palo Alto, CA: 2006. 1013511.

7
LOW-LEVEL WASTE MANAGEMENT AND REDUCTION

Management of Low-Level Waste (LLW) during a decommissioning project has a substantial impact on project timing, cost, duration, and available resources, as well as on disposed waste volumes. The following are some of the most important lessons learned from previous decommissioning projects. Given the large scope of LLW management during decommissioning, there are many more additional lessons from previous plant experiences.

- Plant operators should prepare for a comprehensive site characterization effort before final shutdown or as soon after shutdown as possible. The site characterization is crucial in the development of the LLW management plan and should seek to identify contaminated areas based on surveys and measurements.
- To the extent practical, focus advanced planning for dismantlement and removal activities first on the higher activity waste, including liquid wastes, activated components, and major end items. Due to limited disposal options, such wastes can restrict the scope of the decommissioning project or impact the ability to maintain dismantlement schedules. For major end items, the entire process from initial planning to final disposition require lead times of as much as 2 to 3 years.
- Except for the removal of selected major end items, the handling, processing, packaging, shipping, and disposal of decommissioning waste is within the capability of the LLW staff at most operating plants.
- Decommissioning efforts should focus on plant dismantlement and eliminating radioactive materials from the site rather than equipment decontamination, except when the effort reduces exposure or improves work access. For most decommissioning wastes, off site processing is more cost effective than on site processing. Note that this does not apply to chemical decontamination.
- On site waste volume reduction should be limited to simple, efficient packaging activities and survey/release programs with limited exceptions.
- Plants should remain in touch with regulatory policies, the available waste disposal options, and the waste acceptance criteria for alternative LLW disposal sites. Disposal site availability is a dynamic issue affecting dismantlement, disposal, and storage option. In addition, planners should develop strategies for the storage of greater than Class C waste until the final disposal options are clearer.
- Experiences at plants pursuing incremental decommissioning highlight the benefits of a slow, deliberate process that allows for sufficient advance planning and for changes when new problems or challenges arise.

- Radwaste shipping costs should be minimized by using the maximum shipping container volumes which satisfy transport regulations and truckload weight limits. Larger containers result in fewer shipments and fewer cuts during reactor internal segmentation, which can compress the decommissioning schedule and reduce secondary waste.
- Decommissioning planners should realize that there is no standardized methodology or approach for the removal and packaging of large components. This is an area where plants should seek out experience, assistance, and advice from other plants which have already worked through similar challenges.

Related EPRI Technical Reports

- Decommissioning Low Level Waste Management and Reduction Guide, EPRI, Palo Alto, CA: 1999. TR-110234.

8
INTERIM STORAGE OF GREATER THAN CLASS C WASTE

By 2055, it is estimated that there will be 1300 cubic meters of greater than Class C (GTCC) waste from nuclear reactors containing 88 million curies. Over 90 percent of this activity is projected to come from activities associated with decommissioning nuclear reactors. The Department of Energy has primary responsibility for the development of a national strategy for the disposal of this GTCC waste. Current expectations are that GTCC waste will be disposed concurrently with spent nuclear fuel and high level waste and in the same disposal facility. However, such a disposal facility does not yet exist and there are no specifications for waste acceptance criteria or the technical regulations for a disposal package of GTCC waste. Thus, there exists a need for interim storage of GTCC waste as well as guidance to ensure safe storage of the waste. The following are some of the important lessons learned from plant experience with the interim storage of GTCC waste.

- Since the regulations involving the storage and disposal of GTCC is a dynamic issue and will change over time, it is incumbent upon the reader to remain current with GTCC waste regulatory requirements.
- As of November 13, 2001, GTCC waste may be stored under a general or specific license of 10 CFR 72. This allows plants to terminate their 10 CFR 50 license and store GTCC waste within an independent spent fuel storage installation (ISFSI).
- The most common GTCC waste materials in descending order of frequency include reactor internals, control rods and control element assemblies, cutting dross/swarf, incore detectors, neutron windows, excore detectors, filter liner, and part of the high pressure safety injection nozzle.
- In the absence of waste acceptance criteria for disposal of GTCC waste from the DOE, most plants are proceeding with plans to package and store GTCC waste in the same type of canisters used for spent fuel assemblies and do not anticipate having to repackage the waste. However, consideration should be given to a GTCC storage plan for future repackaging if necessary.
- The issue of whether GTCC waste can be placed in canisters and stored inside the dry cask storage system with spent fuel remains open. Current guidance indicates that GTCC waste can be stored at the ISFSI in containers separate from the spent fuel storage casks, but some licensees are evaluating the possible storage of some GTCC, such as incore detectors and control rods, in the same canisters as spent fuel assemblies. Plants should seek a formal determination from the NRC as to whether this is permissible or not.
- A common form of GTCC is the residue and slag from underwater cutting processes and is termed either dross or swarf. One plant carefully collected and combined all dross/swarf

from a cutting project so that most of it could be disposed as Class C waste. Large pieces were removed and stored as GTCC waste.

- Planning for the maximum size of any material loaded into a storage canister will minimize the total number of cuts during segmentation of reactor internals and has many benefits, including a reduction in the total volume of dross/swarf generated. This is one of the most important decisions made by a decommissioning plant and applies to all waste removed.
- Most, but not all plants, have been able to dispose of excore detectors as Class C waste. Incore detectors may go either way, depending mainly on whether the tips were cut away from the whips, thereby reducing the volume for concentration averaging.
- One nuclear plant was able to package waste that would otherwise have been classified as GTCC waste within the reactor pressure vessel and the entire package was classified Class C waste. This option should be considered by all plants because of its many advantages, but is not an option that is presently available to plants.
- One utility pointed out that some of the GTCC waste removed from the reactor can exceed the general radiation field criteria envelope established by the DOE for fuel canister packages. Utilities should provide enough internal shielding for the canister to ensure that it is within the general radiation field criteria.
- Plants have often found it difficult to match canister design with segmentation and cutting to optimize the size and shape of waste material.

Related EPRI Technical Reports

- Interim Storage of Greater Than Class C Low Level Waste, Rev. 1, EPRI, Palo Alto, CA: 2003. 1007862.

9
APPLICATION OF ROBOTICS TO DECOMMISSIONING

Segmentation of radioactive components, including reactor cavity internals, has proved to be a challenging job for the nuclear power industry during decommissioning. The innovative use of robotic technology to perform debris cleanup can help utilities reduce worker exposure and maximize worker safety. The following are some of the most important lessons learned from robotics experience during the Connecticut Yankee (CY) plant decommissioning.

- CY utilized various robotic equipment in the plant decommissioning (1998-2003).The equipment was used in the sectioning and demolition of highly radioactive components as: contaminated casks, reactor internals, and the reactor head thermal sleeves. Additionally, it was used in the internal inspection and survey of contaminated tanks, in extensive cleanup activities associated with the reactor chemical decontamination and in the final cleanup and demobilization of the reactor cavity following the reactor internals segmentation project.
- The CY experience clearly demonstrated the benefits of using robotic equipment including; in minimizing worker exposure, increased productivity in repetitive high exposure activities, precision and repeatability of movement and overall worker safety. Difficulties in the application of this equipment include such items as: equipment damage due to inexperienced operator, plugging of vacuum collection hoses, higher level of plant support in some applications and need to modify design in some applications due to unforeseen constraints.
- Although there are numerous demonstrated and potential benefits in the use of robotic technology during decommissioning, the use of such equipment is not a panacea for all tasks. The successful application of these technologies requires a thorough execution plan developed by both the decommissioning staff and the robotic vendors. Preparations for robotics work should be as vigorous as if personnel were being used rather than machines.
- A systematic, multidisciplinary approach to the development of the equipment and work plan is the key to success. The team should consist of representatives of the major stakeholders in the task and should include experts in the various disciplines required to plan and execute the work.
- Before selecting a vendor, planners should thoroughly evaluate the total scope of the project, including the specific end points, the constraints on the work, and the desired waste forms and packaging. Vendors with limited nuclear experience can provide excellent service to a project if planners can effectively research available options, determine how project goals match vendor services, and work closely throughout the entire process.
- It is important to ensure that the equipment selected is appropriately sized and powered for the task and that the platform delivering the end-effectors fits the requirements of the work.

- Projects should use multi-use machines if possible. Equipment that is less specialized and has a wider variety of end-effectors will be more adaptable to contingencies and unforeseen challenges.
- A review of the tasks identified should be performed to target those that are complicated, critical to the accomplishment of the scope, or entail a high risk to personnel if they are not successful or performed incorrectly. Tasks with these attributes should be evaluated to determine if more thorough planning is warranted and if training or performance/mock-up testing is required.
- During the work phase, it is important to properly maintain equipment. Daily inspections should be performed while the equipment is in use to ensure its material is adequate and the equipment is structurally sound. A schedule for routine maintenance and checks of fluids and fittings should be implemented in accordance with the vendor's recommendations.

Related EPRI Technical Reports

- Application of Non-Nuclear Robotics to Nuclear Industry Decommissioning, EPRI, Palo Alto, CA: 2004. 1009571.

10
REGULATORY AND STAKEHOLDER INTERACTIONS

Communication is an important element in all decommissioning projects. Many different federal and state agencies regulate the process and community stakeholders may have concerns regarding the activities associated with decommissioning. The following are some of the important lessons learned from plant decommissioning experiences with regulatory and stakeholder interaction.

- It is essential to build trust with the various project regulators and stakeholders. Plants should make efforts to establish confidence with regulators and stakeholders that when issues arise during decommissioning, they will be reported quickly. This is especially important with community relations where distrust can easily arise if stakeholders hear about decommissioning issues first through local media outlets.
- It is important to identify the various stakeholders and develop an appropriate strategy of addressing the concerns of each group. For example, one plant's program included the following stakeholders:
    - Residents within 5 mile radius
    - Businesses within 5 mile radius
    - Community/county leaders
    - News media within area of plant operation
    - Potential opposition groups and leaders

  A formal strategy was developed for reaching these groups and addressing their informational needs.
- Decommissioning plants should make efforts to communicate effectively with community stakeholders. Public meetings with a community advisory panel have been successful in the past. Alternatives include updates in newsletters or advertisements in newspapers describing recent activities at the plant.
- In addition to addressing radiological decommissioning issues, it is equally important for projects to address non-radiological issues in decommissioning. The government agencies responsible for non-radiological hazardous materials may have varying levels of experience with nuclear plants. It is important to develop positive relationships with these agencies in addition to those with previous experience.
- Plants should develop and get agreement on conditions for the site characterization before samples and measurements are taken.

- Negotiation is often better than litigation. Although additional tasks are required to reach negotiated settlements, an assessment of costs and benefits could show that litigation will extend the project length by an unacceptable amount. One plant estimated that if litigation was selected as an overall project approach, the overall completion would have been delayed up to two years.
- It may be reasonable at some plants to expect that interactions with regulators are separate from those with community stakeholders. However, experience suggests that many stakeholder groups involved with plant activities during the operational lifetime will continue to advocate positions during decommissioning. Several plants have made a conscious effort to include stakeholders in discussions of important issues.
- It is a great benefit for community stakeholder interaction to have one or more engineers who can discuss technical issues in a manner people can understand and can answer questions clearly. In past experiences, communication with stakeholders improved as representatives gained experience or received assistance.

Related EPRI Technical Reports

- Fort St. Vrain Decommissioning: Public Relations and Human Resource Issues, EPRI, Palo Alto, CA: 1998. 109030.
- Maine Yankee Decommissioning - Experience Report: Detailed Experiences 1997 - 2004. EPRI,Palo Alto, CA: 2005. 1011734.