In Situ Decommissioning Moves Ahead – 10345

Charles A. Negin, Project Enhancement Corporation
Andrew P. Szilagyi and Yvette T. Collazo, U.S. Department of Energy
Patricia Lee, John Gladden and Roger Seitz Savannah River National Laboratory
Michele Wilson, Savannah River Nuclear Solutions

ABSTRACT

The Department of Energy (DOE) has identified In Situ Decommissioning ("ISD;" or entombment) as a preferred closure strategy for selected facilities. These facilities are generally characterized as being on enduring sites, being of large size and 'hardened' construction, and having significant radiological contamination, with or without chemical contamination. Achievement of the entombed end-state is a result of established regulatory review and approval processes for decommissioning of DOE facilities.

Implementation of major ISD projects is now well under way at three separate DOE sites. At this writing, there has been one completed major project, three major facility projects are in progress, and several smaller facilities have completed or are well along.

DOE work to address the ISD concept, its status, current projects and experience, regulatory aspects and technological opportunities, and recommendations was reported in 2009. The primary publications are a report on ISD strategy and experience within DOE [1] and ISD technological opportunities [2]. This paper summarizes that work.

DESCRIPTION OF IN SITU DECOMMISSIONING

In Situ Decommissioning (ISD) is the permanent entombment[1] of a contaminated facility. "In situ decommissioning" and "ISD" are used to communicate the general concept of permanent entombment as the decommissioning end-state of a facility within the DOE Complex.

An ISD project encompasses a complete facility, although the entire facility may not be entombed; in some cases the scope is limited to the below-grade portion of a facility. The envelope of the project may extend beyond the outer walls. The entombed portions of the facility are of robust construction, generally of reinforced concrete exterior that provides a migration barrier between internal contamination and the environment; with significant internal void spaces backfilled or grouted. The scope of entombment can include ancillary equipment and structures, contain radioactive and hazardous materials and contamination within the facility, and waste imported from outside the facility.

ISD is a permanent decommissioning end-state. The defined completion (the end-state) of the decommissioned facility is project-specific and in conformance with environmental approval processes. The final condition is passive, meaning there are no requirements for ongoing operational systems or equipment within the decommissioned facility. ISD projects are presumed to be under indefinite institutional control of the U.S. Government. Following site closure, the Office of Legacy Management (LM) will assume responsibilities for management and control.

The regulatory framework is currently in place to provide assurance that the risk posed by an ISD facility is within regulatory acceptance criteria. Special emphasis is placed on the fact that an entombed facility is not considered a waste disposal facility; rather it is a decommissioning end-state option.

ISD does not eliminate proper management of contaminated materials and structures, nor does it serve to abandon contaminated buildings in place. Further, ISD is feasible and cost-effective for a very limited number of facilities across the Complex; as described later, the number is judged to be in the range of

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[1] In "entombment," radioactive contaminants are permanently encased on site in a structurally sound material, such as concrete, and appropriately maintained and monitored until the radioactivity decays to a level permitting restricted release of the property.

100–200 structures. As such, the overall combined result of ISD projects will not be a multitude of small buildings littering the landscape at any site or across the country.

THE DEFINITION OF ISD

ISD is not a revolutionary concept. Since the 1970s, the U.S. Nuclear Regulatory Commission (NRC) has recognized the option of entombing a facility as a decommissioning option.[2] Other references to ISD have described the concept as applicable to the decommissioning of offshore oil platforms and large diameter pipelines, for which the regulatory system is completely different; these sources do not address radioactive contamination that is not naturally occurring.

At present, ISD is not addressed in the Department of Energy (DOE) and Office of Environmental Management (EM) lexicon[3]; it is not officially defined within DOE's hierarchy of directives that includes policies, orders, notices, guides, and technical standards. Prior to the issuance of Reference 1, ISD has not been otherwise defined, recognized, endorsed or discussed. However, because it is an important concept that will be in play for many years in the future, the following definition has been proposed for incorporation within DOE documents:

> "In situ decommissioning is the permanent entombment of a facility that contains radiological contamination, with or without chemical contamination. Achievement of the entombed end-state is a result of established regulatory review and approval processes for decommissioning of DOE facilities."

As ISD is a concept that has been used in other industries, it is important that the reference to the DOE be kept in the above proposed definition.

RATIONALE FOR ISD

In many cases, ISD offers the safest, timeliest, and most cost-effective solution. Consideration of ISD as an acceptable end-state to decommissioning is underscored by the following questions:

- Does it make sense to demolish some of DOE's sturdy, hardened facilities, only to transport the remains to a waste disposal site, which may be only a few miles away in some cases, and a few thousand miles away in others (for which the cost would be prohibitively high)? The worker safety and environmental consequences of ISD are comparable to or less than the alternative of complete removal.
- Is the ALARA (As Low As Reasonably Achievable) radiation exposure principle being practiced in which "Reasonably Achievable" refers to the cost element in the ALARA principle? Exposures to workers are typically lower for a less costly entombment option than for more expensive cleanout, demolition, and complete removal.
- Why not turn the liability of these facilities into an asset and use them for permanent placement of selected residual materials? Long-term protection of the public and environment from the entombed radiation sources can be consistent with that of traditional waste disposal sites.
- Is costly complete demolition the best use of limited resources? From a purely budgetary perspective, resources saved by ISD can be used to achieve further risk reduction with other EM scope.

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[2] One reason entombment is not practiced in the commercial nuclear industry is because of the limited availability of suitable locations for siting new power plants.

[3] There is currently no language in key DOE documents that addresses, or even mentions, the practice of in situ decommissioning.

These questions are addressed on a project-by-project basis through the regulatory approval process to determine the decommissioning end-state of a facility. The ISD option is feasible for a limited number of DOE contaminated facilities for which there are substantial incremental environmental, safety, and cost benefits versus alternate actions to demolish and excavate the entire facility and transport the rubble to a radioactive waste landfill.

CURRENT STATUS

ISD has been successfully accomplished at Idaho National Laboratory (INL) and is currently in diverse stages of planning and implementation at Hanford, INL, and the Savannah River site (SRS). Three large and several smaller DOE facilities have been through the CERCLA Record of Decision approval process:

- The U-Canyon is one of five very large, reinforced concrete structures at Hanford and was chosen as the initial facility for the Canyon Disposition Initiative (CDI), which began in 1995. A ROD for the cleanup of the 221-U Facility was issued in October 2005.
- Several facilities at INL, including reactor buildings and test areas, have been or are in the process of ISD closure under CERCLA with an approach that removes significant radioactive contamination. With regard to remaining contamination within a facility, the most significant ISD project to date at INL is the CPP-601/640 fuel reprocessing facility4; an Action Memorandum was issued in August 2008 for its closure.
- At SRS, the P-Reactor Building Complex (part of the P-Area Operable Unit) has received an Early Action Record of Decision (EAROD) for the ISD concept. The EAROD concept is described in the regulatory framework section below.

These projects represent permanent closure although they might not be referred to as "in situ decommissioning" in the associated documentation. There are implementation differences among these sites; these differences result from the physical attributes of facilities and their contents, the types and distribution of radiation, environmental conditions, and local regulatory agreements and preferences. Regardless, they all meet the long-term performance objectives as enforced by the EPA under CERCLA, and by the DOE under the Atomic Energy Act. At all three, the site land use where the ISD facility is to be located is one of assumed Federal institutional control, i.e., maintaining control until the facility can meet the requirements for unrestricted release specified in DOE O 5400.5, *Radiation Protection of the Public and the Environment*. In effect, this means Federal control for the foreseeable future.

POTENTIAL COMPLEX-WIDE SCOPE FOR ISD

The bases for selection of facilities as candidates for ISD are institutional, technical, and safety.

- Institutional feasibility relates to locations at U.S. Government sites where controls will be maintained for the foreseeable future, and ultimately by the Office of Legacy Management. In many cases, such sites already contain low-level waste disposal facilities that have degrees of long-term risk similar to an entombed ISD facility. Institutional feasibility will also tend to rule out urban and suburban locations, as well as other DOE sites where the nuclear mission is clearly not indefinite.
- Technical feasibility relates to candidate facilities of robust construction, primarily some form of masonry, and sufficiently large so that there is a clear advantage to partially demolish and entomb in place compared with complete removal. It is noted that the ISD projects completed and planned to date have a significant fraction of their volume below grade, a factor that contributes significantly to technical feasibility.

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[4] The Old Waste Calcination Facility (CPP 633) at INL can also be considered an in situ closure, although it was conducted using RCRA processes; this was accomplished in 1999. WCF was closed as a RCRA landfill because of extensive contamination.

- While all EM work is approached with procedures and controls to ensure the safety of its workers and the public, ISD offers an equivalent or a safer decommissioning alternative. Entombment limits the radiation exposure to demolition teams because it drastically reduces the handling and movement of the material. Encapsulation in grout prevents migration of contaminants and radiation emission, thereby ensuring the safety of on-site personnel and the public. The long-term risk to personnel and the environment associated with ISD must be shown to be within acceptance criteria applied to other permanent sources located at the same government site. Overall site composite risk analyses include low-level waste disposal facilities and entombed waste tanks, which are comparable examples to an ISD end-state for a contaminated facility.

The most likely facilities for an ISD end-state are the production reactor facilities and the canyon process buildings. Other facilities that have similar methods of construction and contamination are also considered appropriate for the ISD end-state. Using the Facilities Information Management System (FIMS), 84 facilities representing a footprint of about 1.8 million square feet were identified as potential ISD candidates. These were culled by physical attributes and, with few exceptions, are not included in any current plans as ISD projects.

Utilizing FIMS information as a starting point, understanding that there are candidates that cannot be readily distilled from FIMS, and considering known DOE facilities not yet placed in operation and, therefore, not in the database, it is estimated that implementation of ISD could be applicable and beneficial to a limited but significant number of facilities numbering from 100 to 125 across the DOE Complex. Small-sized facilities (of a magnitude of a few thousand GSF) in this number may not be stand-alone projects; i.e., associated with a larger ISD project. Also, ISD may not be effective for other small facilities identified by the culling attributes. A conservative upper bound of 200 facilities accounts for factors that cannot be predicted. This estimated range provides a good perspective on the potential scope of facilities with an ISD end-state. Importantly, this limited number provides the perspective that ISD implementation will not leave hundreds of small entombed buildings scattered about at DOE sites.

Applying documented cost estimates in various RODs to the range of potential total number of ISD facilities derived above, it is roughly estimated that ISD can result in overall, cumulative avoided costs to DOE in the range of $1.5 billion to $3 billion. This is a combination of direct cost avoidance for the ISD approach and the reduced need for waste cells, not only from the reduced demolition waste, but also from the potential of disposing of radioactive waste currently within ISD facilities. In fact, this estimate is likely to be low because many of the cost estimates upon which it was based are dated and the integrated cost of avoided waste cells has not been estimated. Also, many of the facilities to be addressed in the future would have much more severe challenges for complete removal than those that have received RODs to date, thus implying higher unit costs.

REGULATORY FRAMEWORK

The regulatory framework generally applied in ISD is well-defined (e.g. CERCLA removal, remedial or RCRA authority). However, "in situ decommissioning" is a term not specifically included in regulations. The most significant regulatory recommendations, selection, and approval of a facility for ISD are clearly local responsibilities and are to be conducted under the site-specific established regulatory authority (e.g., Federal Facility Agreements with the State and agreements with local stakeholder groups), DOE Orders, CERCLA, RCRA or NEPA per established agreements with EPA and the States.

Use of CERCLA

Consistent with a policy agreement between DOE and the U.S. Environmental Protection Agency (EPA), decommissioning is primarily regulated under CERCLA with DOE regulations (orders, manuals, etc.) considered as appropriate when not sufficiently addressed through EPA's process. CERCLA remedial and removal actions are being used for the three major projects at Hanford, INL, and SRS, with variations as follows:

- The Hanford U-Canyon is a CERCLA remedial action.
- The INL Fuel Reprocessing Facilities (CPP 601 and 640) are a CERCLA non-time-critical removal action.
- The SRS P-Reactor Area has received an EAROD approving the ISD concept using the CERCLA remedial process. A future CERCLA ROD will finalize the details of the ISD alternative.

With regard to the latter, agreement among DOE, U.S. EPA, and the South Carolina Department of Health and Environmental Control leading to the P-Area EAROD allows early remedial actions to occur in conjunction with long-term action to ensure the site is cleaned up as quickly and effectively as possible. The EAROD was completed in compliance with CERCLA and other applicable environmental requirements. This EAROD achieves agreement on the final end-state for the P-Reactor Building and will allow subsequent engineering efforts and regulatory decisions to focus only on closure alternatives that are appropriate for that end-state. The EAROD also allows for consideration of placing remediation waste inside the P-Reactor Building.

Use of an ISD Facility for Placement of Waste

A potential additional benefit could be to use an entombed facility for permanent placement of low level waste (LLW). A clear distinction is intended and must be understood between using an ISD structure for placing radioactive waste versus designating it as a waste disposal facility (siting a waste disposal facility requires a much different regulatory framework and technical approach). In addition to the CERCLA process, an ISD project becomes subject to the requirements of DOE O 435.1 [3] in cases where the decommissioned facility is specifically used for the placement of waste imported from outside the CERCLA Area of Contamination (AOC). Placement of LLW in an ISD facility is technically feasible; however, there are several actions that must be conducted. These include:

- Conducting a DOE 435.1-CERCLA crosswalk to demonstrate compliance with all substantive requirements of DOE O 435.1 that are met through the CERCLA process and to identify additional requirements for which compliance with the former is necessary, if any.
- If not sufficiently addressed in the CERCLA risk assessment, a Composite Analysis (CA) that includes the ISD Facility AOC with other site sources that contribute to the same risk receptors will be needed. CERCLA requires only a risk assessment for the specific facility/AOC being addressed. (In general, it is expected that the CA would be performed during the final closure of the AOC and not through the CERCLA decommissioning analyses.)
- Developing Waste Acceptance Criteria (WAC) specific to the facility under consideration for ISD in projects for which the candidate waste is not explicitly identified in the selected alternative. . An analysis more like a performance assessment conducted for a disposal facility under DOE Order 435.1 may be beneficial to provide the details needed to develop WAC that are not limited by overly conservative assumptions.

TECHNOLOGY DEVELOPMENT

Consistent with the overarching DOE goals for increased personnel and environmental safety, reduced technical uncertainties and risks, and overall gains in efficiencies and effectiveness, EM-40 has initiated efforts to identify the technical barriers and gaps and concomitant technology development needs for the optimal implementation of ISD. An ISD Technology Needs Workshop was conducted in December 2008 to define the ISD technical challenges and explore potential investments in technical breakthroughs. These technologies are expected to improve characterization of existing conditions within ISD candidate facilities; shorten time, lower costs and reduce risks in the execution of ISD work activities; and add confidence to the long term durability of the resultant end-state.

Technology needs identified during the workshop were organized into six basic groups: characterization, materials behavior and degradation, design and closure, monitoring, knowledge management, and policy change. EM-40 will use the portfolio of technical needs from this effort to develop prioritized investment goals that will achieve clear improvements in ISD costs, schedules and safety across DOE's D&D program.

Savannah River National Laboratory (SRNL), as the EM Corporate Laboratory, reported the workshop results [2]. These results and subsequent analyses suggest that EM should prioritize and pursue technology development and deployment to:

- Develop and demonstrate new and alternative fill materials
- Select (and/or develop) and deploy a suite of sensors to verify the performance of near-term ISD projects (subsidence, stress/strain, and fractures)
- Develop an ISD-specific site performance assessment model
- Define and quantify the degradation rates and release mechanisms for concrete structures, activation products from steel, and fill materials.
- Develop and deploy state of the art characterization instrumentation for difficult to sample locations (tanks and sumps), difficult to measure contaminants (long-lived, low-energy, and alpha emitting) by scaling from other radionuclides.

COMMUNICATIONS

Responsibility for ISD planning and execution is with the various DOE Field sites. Communication efforts will be directed by the responsible Field Office through the Federal Project Directors, site managers, and field office public affairs organizations that have a long history and experience in communicating with their regulators, resident neighbors and local stakeholders. Site project and public affairs offices have an understanding of the character and general concerns of these parties, and therefore, are best suited to develop and execute their own targeted and graded campaigns. Some of the groups they might be communicating to include: county residents, native Tribes, citizen advisory boards, state and municipal government agencies and officials, business owners, schools, and local media along with other interested individuals. Staffing, management, timeline, and communication or marketing budgets are established by each individual site. Cost, mix, and exposure are determined by the sites as appropriate for their projects.

In general the communications role for DOE Headquarters would be limited to informing Federal level stakeholders about ISD as the occasion warrants. The goal is to provide information that allows for understanding ISD as a viable decommissioning end-state alternative for specifically selected DOE facilities. ISD information should be provided as needed to communicate the concept initially within DOE and externally at a high level to Congressional staff and other Federal regulatory agencies.

EM has developed a fact sheet [4] for distribution to a general audience that practically describes and defines DOE's strategy for ISD. This user-friendly fact sheet is intended to be shared with all interested parties from DOE program personnel to external stakeholders.

CONCLUSIONS

EM faces the challenge of decommissioning thousands of excess nuclear facilities. Each project will involve the complete deactivation, decommissioning, demolition and transport of the resultant debris of a sturdy, hardened facility and its enclosed contaminated equipment and process systems, including miles of pipelines and tons of volumetrically contaminated structures.

ISD can be part of the solution to this challenge when applied properly and efficiently. The work reported in this paper first serves to define, endorse, and increase the awareness of these projects across the DOE realm. The work also provides information, describes the approaches, identifies constraints and limitations, and points to the path forward for ISD projects.

REFERENCES

1. A. P. Szilagyi, et al, DOE EM Strategy and Experience for In Situ Decommissioning, September 2009.

2. P. L. Lee, et al, Technology Requirements for In Situ Decommissioning; Workshop Report , Savannah River National Laboratory, June 2009

3. DOE O 435.1, Radioactive Waste Management, January 2007

4. Fact Sheet; In-Situ Decommissioning, A Strategy for Environmental Management; can be found on the internet at http://www.em.doe.gov/EM20Pages/PDFs/02-17-09ISDFact%20Sheet-V9.pdf