Lessons Learned: Past to Future

L.W. Camper, D.A. Orlando
U.S. Nuclear Regulatory Commission, Washington, DC

Abstract. The identification, preservation, and incorporation of decommissioning lessons learned are critical to the continued expansion of nuclear power. Decommissioning experience will be developed in Europe and Asia over the next several years that will be invaluable to the decommissioning of the next wave of plants in the United States. Industry and regulators will need to work cooperatively to ensure that the information is preserved and included in the design and operation of all new nuclear facilities, as well as ongoing decommissioning projects. This paper describes the U.S. Nuclear Regulatory Commission's efforts to capture decommissioning lessons learned from the first wave of decommissioning projects.

1. Introduction

The regulations of the U.S. Nuclear Regulatory Commission (USNRC) in Title 10, Section 20.1003, "Definitions," of the *Code of Federal Regulations* (10 CFR 20.1003) define "decommission" as "to remove a facility or site safely from service and reduce residual radioactivity to a level that permits (1) release of the property for unrestricted use and termination of the license; or (2) release of the property under restricted conditions and the termination of the license." On July 21, 1997, the USNRC published the final rule on radiological criteria for license termination (the License Termination Rule or LTR) as 10 CFR Part 20, Subpart E. The LTR established 0.25 millisievert/year (mSv/year) [25 millirem/year (mrem/year)] from all sources of radiation under the licensee's control as the decommissioning criterion for USNRC-licensed sites. In addition, the LTR requires that doses be as low as reasonably achievable and that dose estimates include all sources (or pathways). Finally, the LTR provides for the release of sites for unrestricted use and for their release from regulatory control with restrictions on future site use.

The USNRC regulates the decontamination and decommissioning of materials and fuel cycle facilities, power reactors, research and test reactors, and uranium recovery facilities, with the ultimate goal of license termination. The agency terminates approximately 200 materials licenses each year. Most of these license terminations are routine and the sites require little, if any, remediation to meet the USNRC unrestricted release criteria. However, some present technical and policy challenges, such as contaminated ground water, restricted release, and site-specific dose assessments that require large expenditures of USNRC staff resources.

2. Status of decommissioning facilities

Currently, 16 power and early demonstration nuclear reactors are undergoing decommissioning. Of these, 11 are in safe storage status and 4 are actively decommissioning.

Another 14 research and test reactors have decommissioning orders or amendments. Additionally, three research and test reactors are in "possession-only" status, either waiting for shutdown of another research or test reactor at the site, or for removal of the fuel from the site by the U.S. Department of Energy.

In addition, 32 complex materials sites and 12 USNRC-licensed uranium recovery sites are currently undergoing decommissioning. These licensees include conventional uranium mills and in-situ leach facilities.

The USNRC provides licensing oversight and decommissioning project management to fuel cycle facilities, including conversion plants, enrichment plants, and fuel manufacturing plants. Most of these facilities have been in operation for 20 or more years. As technology improves and operations at these facilities change, the sites often have unused areas with residual contamination.

3. Decommissioning lessons learned

In the mid-1990s, it became apparent that decommissioning a nuclear facility did not constitute a separate set of actions conducted after the "life" of the facility had ended, but rather was an integral stage in the total lifecycle of the facility. Regulators and the nuclear industry now recognize that planning for decommissioning is an activity that must be factored into the design and operation of all nuclear facilities. Because decommissioning is typically undertaken only once for a facility, it is important to identify relevant experiences and lessons, incorporate them into ongoing decommissioning projects, and factor them into the design and operation of new facilities so that future decommissioning projects can be conducted in a safe, timely, and effective manner.

The USNRC has several activities underway to identify, document, and disseminate decommissioning lessons learned, including regulatory issue summaries and an enhanced Web page.

3.1. Regulatory Issue Summary 2002-02

On July 29, 1996, the USNRC revised its regulations (10 CFR 50.82, "Termination of License") to define a new process for decommissioning power reactors. This new process included a requirement for licensees of power reactors to submit license termination plans (LTPs), rather than decommissioning plans (DPs), when they wanted their facility licenses terminated. As a result of these revisions to the regulations, certain licensees must submit either DPs or LTPs to have their facility licenses terminated. These revisions to the regulations require new information or different types of information than previously required. Since the implementation of these revisions, several licensees have submitted either the required DPs or LTPs for USNRC review. On the basis of these reviews, the USNRC has found common areas that have resulted in the agency issuing several requests for additional information and licensees performing special analyses to address those requests. These additional activities result in delays in completing these reviews as well as increased costs to licensees. The staff has reviewed, or is in the process of completing reviews, of several DPs or LTPs. As a result of these reviews, the agency has identified the following lessons learned:

(1) Communications—Early and frequent discussions between USNRC staff and licensees are encouraged during the planning and scoping phase to support the preparation of the DPs or LTPs.

(2) Ground water—Additional environmental monitoring data may be needed because operational environmental monitoring of ground water may not be sufficient for adequate site characterization and dose assessments.

(3) Data quality objectives—The data quality objectives process is encouraged in planning and designing the final status survey (FSS) plan.

(4) Inspections—In-process inspections are more efficient than one-time confirmatory surveys.

(5) Flexibility—Continued communication between USNRC staff and the licensee during the staff's review is encouraged to help the licensee take full advantage of the inherent flexibility in NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual," and NUREG-1727, "NMSS Decommissioning Standard Review Plan."

(6) Modeling issues—Submittal of assumptions and justification for parameters used in developing site-specific derived concentration guideline levels (DCGLs) and application of those DCGLs is encouraged.

(7) Decommissioning cost estimate—The discussion should include a clear relationship between the planned decommissioning activities and the associated updated cost estimate.

(8) Records—Old records should not be used as the sole source of information for the historical site assessment/site characterization because they may be inadequate or inaccurate.

(9) Environmental assessments—Some environmental submittals have not provided sufficient information regarding nonradiological impacts of the proposed action, as required by the National Environmental Policy Act.

(10) Classifications of survey units—DPs and/or LTPs should be submitted only after sufficient site characterization has occurred.

(11) Embedded piping—Some LTPs and DPs have not adequately described the methods the licensees plan to use when surveying the embedded piping that they intend to leave behind.

(12) Minimum detectable concentrations—Some LTPs and DPs have not adequately described the methodologies the licensees plan to implement to scan minimum detectable concentrations of mixtures of radionuclides that may remain in given survey areas/units.

As a result of these findings, the staff has expanded its acceptance review process for DPs and LTPs (typically an administrative review) to include a limited technical evaluation before it accepts a DP or LTP for detailed review. An expanded acceptance evaluation facilitates the identification of significant technical deficiencies early in the review process. This limited technical review focuses on those areas in which experience has shown technical deficiencies in licensee submittals. In general, these areas are (1) site characterization (hydrogeological and radiological), (2) dose modeling, (3) final radiation survey, (4) cost estimate, and (5) institutional controls (applicable only to restricted release).

3.2. Regulatory Issue Summary 2004-08

USNRC staff experience implementing the LTR has revealed some important issues impacting the decommissioning of sites. In June 2002, the USNRC staff conducted an analysis of LTR issues, with particular emphasis on resolving the restricted release and institutional control concerns to make the LTR provisions for restricted release and alternate criteria in 10 CFR Part

20, Subpart E, more available for licensee use. The staff completed its analyses for the following nine areas in March 2004:

(1) Restricted release/alternate criteria and institutional controls—USNRC licensees have difficulties arranging the institutional controls, required by the LTR, that will ensure long-term protection of public health and safety;

(2) Relationship between LTR release criteria and the unimportant quantities criterion under 10 CFR 40.13(a)—The relationship is unclear between the exemption in 10 CFR 40.13(a) for source material that is less than 0.05 weight-percent uranium or thorium and the criteria in
10 CFR Part 20, Subpart E (the LTR), used for decommissioning and license termination. In addition, USNRC needs to clarify that 10 CFR 40.13(a) is not a decommissioning criterion.

(3) Appropriateness of developing a separate uranium/thorium unrestricted release standard—Because LTR cleanup levels can be below the concentration levels found in nature, the appropriateness of developing an unrestricted release standard higher than those in the LTR should be considered. In addition, LTR cleanup levels can be lower than other USNRC regulations or certain State and Federal regulations, and some sites have large volumes of source material, making their cleanup complex and costly.

(4) Relationship between the LTR and onsite disposal under 10 CFR 20.2002, "Method for Obtaining Approval of Proposed Disposal Procedures"—USNRC regulations do not establish a clear standard for approving onsite disposals, although onsite disposals need to be reconsidered under the LTR at the time of license termination.

(5) Relationship between the LTR and the current case-by-case approach for controlling the disposition of solid materials—The relationship is unclear between the dose constraint in the LTR of 0.25 mSv/year (25 mrem/year) for unrestricted use of a site and existing guidance for controlling the disposition of solid materials on a case-by-case basis, particularly for instances where materials and equipment containing residual contamination might be removed from a site approved for unrestricted use after license termination.

(6) Realistic exposure scenarios—Clear guidance is needed for selecting more realistic exposure scenarios to estimate potential doses to the public after termination of the license.

(7) Measures to prevent future legacy sites through changes in financial assurance requirements—Because licensee financial assurance risks may cause shortfalls in decommissioning funding, additional measures are needed to ensure that adequate funds are available to decommission sites.

(8) Measures to prevent future legacy sites through changes to licensee operations—Because licensee operational risks may cause decommissioning problems, additional measures are needed to minimize or mitigate those risks.

(9) Appropriateness of allowing the intentional mixing of contaminated soil—The appropriateness of allowing the intentional mixing of contaminated soil to meet release criteria should be evaluated.

The staff has developed guidance, to be documented in a revised NUREG-1757, "Consolidated Decommissioning Guidance, Decommissioning Process for Materials Licensees," to address these issues.

3.3. Enhanced Web page

In 2005, the USNRC established a decommissioning lessons learned page on the new decommissioning Web site. This Web page includes a definition of lessons learned, which are any items that could be of interest and benefit to many licensees. Lessons learned include positive or negative experiences that are worth sharing with USNRC licensees and stakeholders to improve future efficiencies. The Web page provides a short summary of each lesson, its potential benefits, and links to publicly available documents that discuss each lesson learned in further detail. The Web page includes links to existing published sets of USNRC lessons learned. USNRC lessons learned can be found at http://www.nrc.gov/what-we-do/regulatory/decommissioniong/lessons-learned.html.

4. Implementing the lessons learned

4.1. Materials sites

The staff has significantly improved the USNRC's decommissioning program in terms of flexibility and the use of realistic scenarios, supported by adequate justification for the choice of the scenario. The USNRC has used these innovations to establish site-specific cleanup levels at a number of sites.

For example, at one materials site, the staff developed its own dose assessment to support a recommendation to the Commission of no further decommissioning action. The dose assessment considered a range of potential scenarios that included two reasonably foreseeable scenarios and two less likely scenarios to bound the uncertainty associated with future land use.

Another materials site proposed an industrial land use scenario for dose calculation purposes. The USNRC staff reviewed the proposal and evaluated land use development in the area to conclude that industrial land use was appropriate for this site. This decision represented the first case that used the industrial scenario as a reasonably foreseeable land use and that withstood a legal challenge.

At another site, the licensee used the realistic scenario approach and the flexibility of the LTR to design an engineered barrier for erosion protection in revising and resubmitting its DP.

Yet another site used the realistic scenario approach to facilitate license termination, resulting in leaving the contamination undisturbed, avoiding impacts to workers and the environment, and minimizing the decommissioning costs.

4.2. Reactor sites

In 2005, the USNRC completed decommissioning at two power reactor sites that, while similar, elected two different approaches to decommissioning. One reactor site elected to complete decommissioning, terminate the operating license under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," and manage the independent spent fuel storage installation

(ISFSI) under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste" (specific license). The other site elected to shrink the plant footprint to the ISFSI and continue to manage the ISFSI under the general license provisions of 10 CFR Part 50. These different approaches identified several lessons, as discussed below.

4.2.1. Stakeholder communications

The LTR requires that the USNRC solicit comments from the public, and 10 CFR 50.82 requires that the agency hold a public meeting before approving the LTP for power reactors. This meeting allows the public to present concerns to the USNRC staff as it reviews the LTP. Stakeholder participation can vary widely and can result in stakeholders taking significant actions that may impact a licensee's DP.

4.2.2. LTP development and implementation

Licensees need to produce a clear, concise, and detailed LTP to achieve faster approval. Furthermore, a clearly written LTP requires less interpretation and allows the USNRC to easily verify compliance with approved LTP requirements. The following discussion describes how two sites' LTPs affected the decommissioning process.

At one site, the licensee took a straightforward approach to the LTP and decommissioning. The original site characterization found no ground water contamination, so the licensee adopted the USNRC screening-level DCGLs instead of developing site-specific DCGLs. This simplified the approach for demonstrating that the residual radioactivity would be less than the 0.25 mSv/year (25 mrem/year) criterion. The licensee sought to release the site for unrestricted use. The USNRC approved the LTP in 18 months. Over the course of the decommissioning, the LTP required no major revisions.

In contrast, the licensee for another site wrote its LTP with very broad and general methods for demonstrating compliance with USNRC requirements and guidance. Although licensees generally believe that a less-specific LTP allows for greater decommissioning flexibility, it increases the potential for differing interpretations of the LTP commitments by the USNRC and licensee staffs. In this case, the different interpretations during the LTP review led to numerous meetings and teleconferences to resolve USNRC questions, ultimately requiring 37 months for LTP approval.

4.2.3. Final status survey records and confirmatory surveys

A licensee uses the final status survey report (FSSR) to demonstrate that residual radioactive material at the site does not exceed the USNRC criteria for release of the site. The USNRC reviews the FSSR to verify that the results of the FSSs demonstrate that the site meets the radiological criteria for license termination. As part of the FSSR review process, the USNRC may evaluate a variety of records associated with the FSSR, such as actual survey data packages, FSS instrument calibration records, and survey technician qualification and training records. The licensee and the regulator should agree on the format and content of the FSSR records that support the FSSR (i.e., FSS data, instrument calibration logs, and technician qualification and training records). These records should be readily retrievable for inspection and of high administrative quality.

At one site, the licensee submittals followed the original agreed-upon format, were consistent, and were of high administrative quality, which allowed the USNRC staff to review the information efficiently. The USNRC scheduled confirmatory surveys with the licensee and performed them as planned.

In contrast, the content of the FSSR for another site consisted of general FSS records. In this case, the USNRC staff needed to ask for substantially more information and conduct two additional site inspections. At this site, the USNRC review took longer to complete. Furthermore, the USNRC had difficulty in scheduling confirmatory surveys; instead, scheduled surveys took place concurrent with in-process surveys.

5. Conclusion

The USNRC is working cooperatively with the nuclear industry on approaches to identify and preserve decommissioning lessons learned because decommissioning knowledge management is critical to the continued expansion of nuclear power. Decommissioning experience will be developed in Europe and Asia over the next several years that will be invaluable to the decommissioning of the next wave of plants in the United States. Industry and regulators will need to work cooperatively to ensure that the information is preserved and included in the design and operation of all new nuclear facilities, as well as ongoing decommissioning projects.

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