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## UNITED STATES NUCLEAR REGULATORY COMMISSION PROGRAM FOR INSPECTION OF DECOMMISSIONING NUCLEAR POWER PLANTS

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### INTRODUCTION

The United States Nuclear Regulatory Commission (USNRC or Commission) has been inspecting decommissioning commercial nuclear power plants in the United States (U.S.) since the first such facility permanently shutdown in September 1967. Decommissioning inspections have principally focused on the safe storage and maintenance of spent reactor fuel; occupational radiation exposure; environmental radiological releases; the dismantlement and decontamination of structures, systems, and components identified to contain or potentially contain licensed radioactive material; and the performance of final radiological survey of the site and remaining structures to support termination of the USNRC-issued operating license. Over the last 5 years, USNRC inspection effort in these areas has been assessed and found to provide reasonable confidence that decommissioning can be conducted safely and in accordance with Commission rules and regulations. Further, the level of inspection effort is consistent with the low level of risk associated with accidents possible during decommissioning activities such as storage of radioactive materials, dismantlement, site remediation, and decontamination of structures, systems, and components.

Recently, the staff has achieved a better understanding of the risks associated with particular decommissioning accidents<sup>1</sup> and plans to apply these insights to amendments proposed to enhance decommissioning rules and regulations. The probabilities,

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<sup>1</sup>NUREG-1726, "Predictions of Spent Fuel Heatup after a Complete Loss of Spent Fuel Pool Coolant," July 2000, and "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," October 2000, located on the USNRC website at <http://www.nrc.gov/NRC/REACTOR/DECOMMISSIONING/SF/index.html>.

scenarios, and conclusions resulting from this effort are now being assessed as to their applicability to the inspection of decommissioning commercial power reactors.

## **MISSION OF USNRC INSPECTION**

The USNRC, pursuant to the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 (42 U.S.C. 56801 *et seq.*)) serves, in part, to protect public health and safety, protect the environment, and protect and safeguard nuclear materials and nuclear power plants in the interest of national security. In implementation of its responsibilities, the Commission performs inspections of licensed facilities to identify situations or conditions of regulatory noncompliance. These inspections also have the collateral result of identifying conditions adverse to safety thereby providing opportunity to prevent unsafe situations from occurring. Commercial power reactor licensees are required to permit inspection, by duly authorized representatives of the Commission, of its records, premises, activities, and of licensed materials in possession or use, as may be necessary to carry out the USNRC mission.

## **INSPECTION PROGRAM DEVELOPMENT**

In August 1997, USNRC Inspection Manual Chapter (IMC) 2561, "Decommissioning Power Reactor Inspection Program," was revised to incorporate lessons learned and insights from the 1996 amendment (61 FR 39278) of the decommissioning regulations contained in Title 10 of the Code of Federal Regulations (10 CFR), Parts 2, 50, and 51 (*Federal Register* notice 39278, Vol. 61, July 29, 1996). The changes to these regulations clarified regulatory ambiguities, enhanced uniformity in the decommissioning process, codified procedures that reduced regulatory burden, and specified the process for greater public participation in decommissioning. The changes also removed any USNRC approvals that were previously necessary for decommissioning. This placed increased responsibility for safety reviews of decommissioning activities on the licensee.<sup>2</sup> An accompanying effect of the amended regulations was that they enhanced USNRC attention on ensuring that site radiological conditions at license termination assured public health and safety and protection of the environment.

In justifying the amended regulations, a number of conclusions were made regarding the potential safety consequences associated with decommissioning. In particular, during the decommissioning stage, the potential radiological consequences that could result from an inadvertent nuclear reaction are highly unlikely. The systems required for maintaining the spent fuel in the spent fuel pool (SFP) as well as the operations required to contain the

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<sup>2</sup>Prior to the 1996 amended regulations, licenses were precluded from commencing decommissioning activities until the USNRC reviewed and approved a licensee-proposed decommissioning plan and a supplemental environmental report.

remaining residual radioactive contamination in the facility and SFP are relatively simple, when compared to that of an operating reactor facility. Further, the activities performed by a decommissioning licensee do not have a significant potential to impact public health and safety and these activities require considerably less regulatory oversight. Moreover, the nature of maintaining and controlling a nuclear reaction and the complexity of systems and operations requirements necessary to prevent and mitigate adverse radiological consequences during decommissioning require considerably less automation, fewer if any immediate and exigent actions by the plant staff, and significantly less concern for control of the nuclear fission process. Also, a permanently shutdown plant does not generate large amounts of thermal energy, avoiding material degradation and stress. Recognizing these considerations and acknowledging that licensee control of facility tests, design changes, and modifications during decommissioning is similar to that undertaken by the licensee while its plant was in operation, it was found that change control processes used during reactor operation (conducted pursuant to 10 CFR 50.59) could be used to conduct decommissioning, if license conditions and the level of USNRC inspection oversight are commensurate with the status of the facility being decommissioned. Licensees were now able to conduct decommissioning without NRC pre-approval by using processes already in place at the facility, and USNRC inspection effort should be commensurate with the potential risk involved.

Building upon the above insights, the staff also listened to comments from the various internal-USNRC stakeholders to help focus and reassess the distribution of inspection effort divided among the areas described in the introductory paragraph of this paper. This effort was augmented by an endeavor to ensure that the appropriate USNRC technical discipline (i.e., what USNRC Office) has lead regulatory oversight responsibility during the different phases of decommissioning that all commercial power reactor licensees must transition through. This becomes most important as a licensee orchestrates its transition from reactor power operation to the achievement of safe shutdown and core offload, through dismantlement and decontamination of structures systems, and components, and into the final phases of decommissioning: the final site survey, radiological characterization, and dose assessment to support unrestricted release<sup>3</sup> of the site and termination of the USNRC-issued 10 CFR Part 50 license.

The USNRC staff also implemented a public outreach program to solicit and obtain comment from the public and nuclear power industry representatives. In particular, the staff conducted public meetings with these stakeholders to foster dialogue and discussion on inspection scope and effort. The goal of these meetings was to assess whether additional program changes were required to achieve reasonable assurance that the program is protective of public health and safety and the environment. Although these public outreach initiatives did not result in the identification of any significant programmatic deficiencies in the staff proposal, the initiative provided an opportunity for the public to voice concerns.

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<sup>3</sup>Restricted release may be requested in cases where radiological requirements for license termination are not met (10 CFR Part 20, Subpart E).

The discussions that occurred during these meetings confirmed that the proposed changes were adequate in the eyes of the industry and public.

## **DECOMMISSIONING EXPERIENCE**

The commercial nuclear power industry in the U.S. is mature and the majority of facilities that have permanently shutdown have seen many years of reactor operation. Almost all of the plants currently in operation have been in operation for more than 10 years, and half of them have operated for more than 20 years. Interestingly, of the commercial power plants that permanently ceased reactor power operation more than 5 years ago, most have elected to place their units immediately into a safe storage configuration, with little immediate site activity to dismantle and decontaminate the facility. Only within the last 5 to 7 years have licensees of these long-term shutdown units taken first steps to conduct significant activities leading to license termination. Regarding the other units that have shutdown after about 1996, three licensees have opted to immediately commence decommissioning-related activities with the goal of USNRC license termination within about 7 years of permanent shutdown. These units initiating the DECON decommissioning option were single-unit reactor sites. The remaining two licensees placed their units in long-term safe storage to be followed by decontamination and dismantlement (i.e., the SAFSTOR decommissioning option).<sup>4</sup> These licensees had either other operating reactor units onsite or other operating reactor units within their corporate infrastructure.

So what does this mean from an inspection perspective? Simply, it means that there is a wide diversity of decommissioning activities in the United States. Further, the diverse decommissioning history in the U.S. has not lent itself well to the identification of generic decommissioning considerations, experiences, and insights that would be reasonably applicable to all current and future power plant shutdowns. Consequently, this necessitates an inspection program that is both effective and flexible in its applicability to any decommissioning scenario.

Until about 1990, the USNRC staff believed that the majority of commercial power reactors would operate until end-of-licensed life (40 years) and then either notify the Commission of its decision to seek license extension or commence decommissioning. However, looking back at the first shutdowns, the reasons for permanent shutdown were very site-specific and, similar to the decommissioning options implemented by licensees described above, did not lend well to the identification of any trend or generic consideration. For some reactor units that shutdown after about 1996, the decision to permanently shutdown the reactor occurred relatively quickly when efforts to return the unit to operation became increasingly more difficult to economically justify. Hence, licensee decisions to permanently shutdown the most recent decommissioning reactor units were predominately

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<sup>4</sup>NUREG-0586, Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, August 1988.

precipitated by economics (sometimes linked to safety concerns that resulted in the long-term plant shutdowns) and not by end-of-licensed life.

To meet the challenge of the changing and diverse decommissioning environment, the inspection program was designed to recognize and accommodate all decommissioning scenarios and incorporated risk insights to implement an appropriate level of USNRC regulatory inspection for a particular site.

**INSPECTION MANUAL CHAPTER: OVERVIEW**

USNRC regulatory oversight (Table 1) of decommissioning commercial power reactors has three key performance areas: safeguards, which consists of a physical protection safety cornerstone<sup>5</sup>; spent fuel safety which involves the safety cornerstones of barrier integrity (comprising of initiating events and mitigating systems) and emergency preparedness; and radiation safety which includes the cornerstones of occupational, public, and environmental radiation protection.

Table 1: Regulatory Oversight

NRC Mission:	Protection of Public Health and Safety and the Environment		
Performance Areas:	<u>Safeguards</u>	<u>Spent Fuel Safety</u>	<u>Radiation Safety</u>
Cornerstones:	Physical Protection	Barrier Integrity Emergency Preparedness Environmental	Public Occupational Environmental
<u>Cross-Cutting Elements:</u>	Human performance Attention to safety and worker's ability to raise safety issues Ability to find and fix problems (i.e., the licensee's corrective action program)		

The decommissioning oversight program also features three cross-cutting elements, so named because they are activities or designs that affect most or all safety cornerstones. These cross-cutting elements are: human performance; management attention to safety and worker's ability to raise safety issues; and licensee's ability to find and fix problems (i.e., the licensee's corrective action program).

In August 1997, the staff implemented a major revision to the USNRC inspection program (IMC 2561) with the ultimate goal of improving the Commission's efficiency and effectiveness in identifying potential safety concerns and conditions of regulatory

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<sup>5</sup>Safety Cornerstones - Nuclear plant activities or design that are essential for the safe operation of the facility.

noncompliance. A secondary goal was to reduce regulatory burden on the decommissioning licensees, consistent with the assessments associated with the 1996 decommissioning rulemaking described earlier.

Prior to the revision of the inspection program, there were two independent inspection programs implemented at a decommissioning facility. One program covered the period from permanent cessation of power operation until the time when all fuel was safely stored in an independent spent fuel storage facility (ISFSI) or transferred to another licensed spent fuel storage facility. Then after the fuel was safely removed from the SFP and stored in a different licensed facility (such as an independent spent fuel storage installation), a second program was implemented to, in effect, shift regulatory inspection oversight to license termination activities such as radiological characterization, final status surveys, and radiological dose assessment. The combining of these two programs was a major element in the 1997 program revision.

Having two separate inspection programs for one licensee implementing decommissioning was not only inefficient from an internal-USNRC perspective, but from a licensee and public perspective as well. Further, the two programs represented a regulatory burden on licensees because the programs did not share common inspection goals and objectives, regulatory and safety focus, or performance standards.

#### Inspection Program - Specifics

The objectives of the decommissioning inspection program are to obtain information through direct observation and verification of licensee activities to determine whether the reactor facility is being decommissioned safely, that spent fuel is safely stored onsite or transferred to another licensed facility, and that site operations and license termination activities are in conformance with applicable regulatory requirements, licensee commitments, and licensee management controls. It is also an objective to identify declining trends in licensee performance, perform inspections to verify that the licensee has resolved the issue(s) before performance declines result in issues of noncompliance or a condition adverse to safety, and effectively allocate USNRC inspection resources. Further, the program verifies that licensee management systems for decommissioning are adequate and provides reasonable assurance that activities will be conducted safely. These systems include, but are not limited to management and organizational effectiveness; self-assessment, auditing, and corrective actions; design control; and independent safety oversight.

The decommissioning inspection program commences following licensee certification that all nuclear fuel has been safely and permanently removed from the reactor vessel and the program continues during and up through license termination. Because decommissioning of power reactors may take a few years or up to 60 years, decommissioning activities may range from relative inactivity (for example, periods of long-term safe storage) to periods of significant or high activity that have a greater potential to challenge public health and safety or the environment. Consequently, flexibility in the management of inspection resources is a key program consideration.

There are two major types of inspections: core inspections and discretionary (i.e., reactive and initiative) inspections. The core inspection element is a set of procedures to be accomplished at every decommissioning reactor facility. These procedures include but are not limited to those listed in Table 2. The list of discretionary inspection procedures is quite a bit longer than the core procedures and, in general, focuses on the same functional areas, however, they tend to be more specific and more technically oriented.

Table 2: Decommissioning Inspection Program Functional Areas

<b>Functional Areas</b>
<p>Area 1: Facility Management and Control</p> <ul style="list-style-type: none"> <li>- Organization, Management, and Cost Controls</li> <li>- Safety Reviews, Design Changes, &amp; Modifications</li> <li>- Self-assessment, Auditing, and Corrective Actions</li> <li>- Performance and Status Reviews</li> </ul>
<p>Area 2: Decommissioning Support Activities</p> <ul style="list-style-type: none"> <li>- Maintenance and Surveillance</li> <li>- Cold Weather Preparations</li> <li>- Physical Security</li> </ul>
<p>Area 3: Spent Fuel Safety</p> <ul style="list-style-type: none"> <li>- Wet fuel storage, handling, maintenance, etc.</li> <li>- Independent spent fuel storage installations (dry storage)<sup>6</sup></li> </ul>
<p>Area 4: Radiological Safety</p> <ul style="list-style-type: none"> <li>- Occupational Radiation Exposure</li> <li>- Radioactive Waste Treatment &amp; Environmental Monitoring</li> <li>- Inspection of Final Surveys</li> <li>- Solid Radioactive Waste Management and Transportation</li> </ul>

USNRC decommissioning inspection procedures are written to be performance based, which means that inspectors should base findings, observations, and conclusions on plant/site activities conducted by the licensee and observed by the inspector. However, a very important element is the accomplishment of inspection prior to the licensee starting or implementing the specific activity. Only in this way, can an inspector have reasonable opportunity to identify a condition adverse to safety or item of noncompliance prior to it occurring, thereby serving to protect public health and safety. Examples of licensee activities that are typically inspected prior to the licensee initiating them are listed in Table 3.

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<sup>6</sup>USNRC Inspection Manual Chapter 2690, Inspection Program for Independent Spent Fuel Storage Installations, is implemented by a separate NRC program office.

Table 3 - Activities Typically Subject to Pre-Inspection

<b>Activities Typically Subjected to Pre-Inspection</b>
Primary system chemical decontamination
Removal and shipment of major radioactive components <ul style="list-style-type: none"> <li>- reactor vessels</li> <li>- steam generators and pressurizers</li> <li>- other components contaminated to a comparable degree</li> </ul>
Installation of new or temporary spent fuel pool cooling systems
Spent fuel pool cleanup activities
Wet and dry spent fuel handling
Control room inactivation
Heavy load operations in the vicinity of the SFP
Radioactive waste shipments (solid material)
Radioactive effluent releases (gaseous or liquid releases)

During periods of long-term safe storage or relative inactivity, inspection of licensee documents describing controls, processes, and procedures provides a level of assurance that activities will be conducted safely. In this case, inspectors will evaluate whether (1) licensee documents are adequately implemented, maintained, and reflect the status of decommissioning; (2) organization, controls, and quality assurance programs are effective; and (3) radiation measurement programs provide accurate control, quantification, and classification of radioactivity.

### **LICENSE TERMINATION**

On July 21, 1997, the USNRC published the final rule on "Radiological Criteria for License Termination" as Subpart E to 10 CFR Part 20 (62 FR 39058). Subpart E establishes criteria for the release of sites for unrestricted use, if the residual radioactivity that is distinguishable from background results in a total effective dose equivalent to an average member of the critical group that does not exceed 0.25 milliSievert per year (mSv/yr or mrem/yr), including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA, see 10 CFR 20.1003). Subpart E also establishes criteria for license termination with restrictions if radiological conditions exceed the 0.25 mSv/yr limit, as long as institutional controls are established and other specified radiological dose limits are not exceeded (10 CFR 20.1403).

The inspection of license termination activities provides reasonable assurance that radiation exposure resulting from the radioactive contamination or activation of structures, systems, components, and land left remaining at the site will satisfy the Commission's radiological criteria cited above. Since decommissioning has the ultimate goal of USNRC license termination, so too must inspection. Therefore, there is significant effort in evaluating, assessing, and verifying licensee actions to remediate, survey, and characterize the radioactive contamination onsite. This coordinated effort will typically employ a team of inspectors to inspect all aspects of license termination. This effort will often be supplemented by a number of individual inspections, a series of meetings between the licensee and the USNRC, and survey and analysis expertise from one of the many independent U.S. laboratories.

### **INSPECTION EFFORT AND PLANNING**

Each inspection procedure details the estimated average times (i.e., direct inspection effort) necessary to adequately complete the inspection objectives at one reactor unit actively pursuing dismantlement and decontamination (see procedures listed in Table 2). These estimated hours are based on experience and updated periodically. It is expected that total inspection hours for a particular site will vary between sites depending on considerations described below. In particular, site-specific inspection hours will be scaled or graduated between a high and a low level of inspection oversight. This scaling of effort illustrates the risk-informed<sup>7</sup> nature and performance-based element of the program. In this way, management of inspection resources is dependent on actual site activities and independent of what decommissioning option the license is implementing.

A high level of inspection would apply to a licensee who is actively dismantling, decontaminating, or performing activities that contribute to license termination. Also high activity includes but is not limited to major decommissioning activities (10 CFR 50.2) or periods of decommissioning in which the aggregate of licensed activities represents a significant change in facility configuration, increase in occupational dose, relocation of radioactive material, or decommissioning cost expenditure. In these cases, an increased level of inspection effort is warranted. When a licensee has either elected to maintain the facility in a true SAFSTOR configuration or decided to incrementally dismantle, decontaminate or decommission structures, systems, or components at such a low rate or small volume that there are only trivial changes in facility configuration, occupational dose, relocation of radioactive material, or decommissioning cost expenditure, a much lower level of inspection effort will be planned.

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<sup>7</sup>Risk-Informed - Incorporating an assessment of safety significance or relative risk in USNRC regulatory actions.

### Inspection Planning and Implementation

The USNRC Regional Offices<sup>8</sup> will decide on the appropriate level of direct inspection effort to apply to the core inspection procedures to provide reasonable assurance of public health and safety and protection of the environment. This latitude in program implementation is appropriate considering the wide range of activity and risk associated with the various phases of decommissioning. Prior to the start of decommissioning and then periodically thereafter, regional managers assess licensee performance and activities to determine the next year's level of inspection effort and inspection schedule. This site-specific schedule is the Master Inspection Plan.

Master Inspection Plans (MIPs) are developed or updated biannually to schedule the conduct of USNRC inspection at a particular reactor facility. These plans facilitate the efficient allocation of inspection resources by listing the planned inspection procedure, associated direct inspection effort, lead inspector, and dates of inspection. In developing MIPs, every core procedure will be accomplished and discretionary procedures will be planned as required. The MIP will also be dependent upon reactor facility design; whether it is located at a multi-unit site; enforcement actions and history; identified safety concerns (i.e., allegations); licensee events; material condition; and status of licensee commitments. Regional management will often meet senior licensee representatives and tour the facility to understand the licensee's plans to decommission and to see first hand the status of the facility.

USNRC will typically plan approximately 800 hours of direct inspection per year on a single unit reactor facility determined to have a high level of activity, compared to a unit in long-term safe storage configuration which would have about 100 hours planned. These direct inspection hours are only guidance and should be biased by risk insights and the considerations above. Sufficient programmatic latitude is provided in the management of USNRC inspection resources.

### **STATE OVERSIGHT**

States will typically monitor and evaluate licensee activities during decommissioning. Recently, some States have become very involved so as to station their own inspectors at the facility, conduct split sampling of radiological samples, and promulgate suggestions if not requirements on the licensee. The USNRC inspection program takes no credit for State oversight activities, however, the staff will typically coordinate with all affected States to reduce regulatory burden and foster independent verification that licensed activities are being conducted safely.

### **USNRC INSPECTORS**

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<sup>8</sup>USNRC Regional Offices are located in King of Prussia, Pennsylvania; Atlanta, Georgia; Lisle, Illinois; and Arlington, Texas.

USNRC inspections at commercial reactor facilities are conducted by trained and qualified individuals. All inspectors undergo a rigorous qualification process and oral boards prior to certification. Following inspector certification, all inspectors receive periodic training in their functional disciplines and generic training to broaden their skills.

USNRC inspectors have unrestricted access to licensed activities, records, and procedures (10 CFR 50.70). Inspectors routinely observe licensee meetings, hold discussions with plant management, observe the conduct of licensed activities throughout the facility, and write inspection reports that are publically available. USNRC inspectors represent a multitude of technical disciplines ranging from health physics and electrical engineering to environmental sciences. USNRC inspectors do not have any review or approval responsibility or authority associated with the operation or decommissioning of any reactor facility.

The decommissioning inspection program provides guidance for stationing an inspector at a particular decommissioning commercial power facility. During reactor operation, typically two resident inspectors are assigned to a single-unit facility to provide full time regulatory oversight. After an operating facility conducts its final reactor shutdown and transfers its spent reactor fuel to the SFP, one inspector will be transferred from the site and the remaining resident inspector will continue providing onsite coverage for about one year to provide reasonable assurance that the facility transition into decommissioning occurs safely and in accordance with Commission rules and regulations. For specific decommissioning activities, such as removal of major components or fuel handling, an inspector may be assigned to the site during the course of the activity.

## **PUBLIC INVOLVEMENT**

As described earlier, the USNRC staff implemented a public outreach program to solicit feedback regarding proposed changes to the Commission's program for the inspection of commercial power reactors that have permanently ceased power operation. Following two years of program implementation, another public meeting was conducted to again solicit public input.

Regional Offices have also provided opportunities for public involvement in decommissioning inspections. These opportunities are in the form of occasional public observation at inspection entrance and exit meetings and presentations to interested members on the inspection program. Early in decommissioning, the staff will typically conduct two public meetings in the vicinity of the shutdown reactor facility to describe the inspection program, recent findings, and areas of potential concern. These meetings are moderated by a person independent of both the USNRC and licensee. In such forums, the staff believes that the public is offered a reasonable and timely opportunity to make comment and share their concerns regarding decommissioning and the regulatory oversight of such activities. The USNRC individuals participating in public meetings will routinely introduce the staff assigned to inspect the particular site in an effort to demonstrate that the inspectors have credible certifications, training, and are fully capable to independently and critically assess licensee performance. The staff has found that

these public outreach initiatives have contributed to increased public confidence in USNRC regulatory oversight.

### Citizen Awareness Committees

Based on experiences gained following the reactor accident at Three Mile Island, Unit 2, Regional Offices have made presentations to local citizen awareness committees which are typically formed and initiated by the licensee. Committee members generally represent a reasonable cross-section of the general public and present a wide variety of opinions and experiences. Although, licensees may help orchestrate and fund a committee, once established, the committees are generally independent and not appreciably impacted by licensee views. The staff has found that citizen's committees foster dialogue between the licensee and public and have a net contribution in increasing public confidence in decommissioning safety.

### **CONCLUSION**

Historical decommissioning information has not predicted well future decommissionings, and risk insights and quantitative risk evaluations of permanently shutdown reactors have only recently been undertaken. However, the USNRC staff has taken appropriate steps to improve its program from the application of risk insights to the involvement of the general public and decommissioning industry in shaping the inspection program. The staff believes that a balanced inspection program will serve in the best interest of the public. This program will apply quantitative and qualitative risk assessments to inspection and provide periodic evaluation of licensee performance and planned decommissioning activities. Further, some minimum level of inspection must be performed to provide reasonable assurance that activities will be conducted in accordance with Commission rules and regulations. Because of the wide variation in decommissioning options available to a licensee, the scaling of inspection resources as provided in the USNRC inspection manual for decommissioning commercial power reactors lends to reasonable assurance and increased public confidence that decommissioning can and will be conducted safely, without excessive burden on licensees.