Decommissioning plant owners are concerned about the disposition of millions of pounds of solid materials from plant demolition. (Photo courtesy Maine Yankee)

Eluding Consensus

Free Release Standards for Decommissioning Projects

This article, developed under the aegis of the American Nuclear Society's Special Committee on Site Cleanup and Restoration Standards, summarizes the issues, the progress, and the limitations of efforts in the area of free release standards and their impact on decommissioning projects and costs.

By Jas Devgun

The recent reemergence of nuclear power as a viable energy option has meant that most reactors that potentially would have been slated for decommissioning are now being prepared for license extension. Thus from both industry and regulatory perspectives, issues related to decommissioning are generally no longer on the front burner. Nevertheless, some issues continue to need resolution. Lack of regulatory standards for the free release of solid materials is one such issue. (Note: In this article, free release and clearance are used interchangeably.)

The nuclear community in the United States has substantial experience in decommissioning, because more than 70 test, demonstration, and power reactors have been decommissioned since the 1960s. Eventually, all reactors, including those whose licenses are being extended, will undergo decommissioning. Also, many nuclear facilities in the federal sector are being retired from service because they are no longer needed in the post–Cold War era. These decommissioning projects involve very large quantities of solid materials such as equipment, metal, concrete, and demolition debris. The disposition of these ma-

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terials—and, hence, the free release criteria—have a significant impact on the overall decommissioning cost.

The regulatory framework applicable to the issue of release of solid materials continues to be in a transition phase, albeit lately in a stalemated situation. While in the past *Regulatory Guide 1.86* (U.S. Atomic Energy Commission, 1974) has formed the basis for cleanup levels, the U.S. Nuclear Regulatory Commission has pursued rulemaking efforts in the past several years to develop dose-based criteria. Though the NRC established the dose-based rule for license termination in 1997, the rulemaking effort for the release of solid materials with residual radioactive contamination has been progressing rather slowly. The most recent activity in this area has been the release of the National Academy of Sciences (NAS) report in March 2002, "The Disposition Dilemma: Controlling the Release of Solid Materials from Nuclear Regulatory Commission–Licensed Facilities," a study commissioned by the NRC.

Paying for Decommissioning and Paying for a Regulatory Void

The decommissioning costs for commercial power reactors vary with the size of the reactor, its type, regulations, cleanup criteria, application of technologies, and access to a disposal site. Generally, such costs are in excess of $400 million for a full-sized reactor.

Of the estimated total cost of approximately $40 billion for decommissioning the nation's fleet of nuclear power plants, about $30 billion had been collected in the decommissioning funds by the end of year 2000. The net result has been that the decommissioning funds for most of the reactors are thought to be at adequate funding levels.

It should be noted, however, that the NRC minimum fund requirements (10 CFR 50.75 (b)) do not include costs of dismantling structures that are not radioactive or the cost of site restoration. Yet many of the decommissioning projects have to contend with such costs. Generally, reactor licensees want to release the decommissioned sites for unrestricted use and restore these sites to greenfield conditions. An important aspect of site restoration is the removal of large amounts of debris that may or may not have small amounts of residual radioactivity.

Based on the estimates in the NAS report, mentioned earlier, disposition of bulk materials (concrete and metal) from decommissioning of all of the nation's nuclear power plants could cost from $4.5 billion to $11.7 billion based on the current costs and depending on the low-level radioactive waste disposal site chosen. If a decommissioning-focused regulatory mechanism were in place and slightly radioactive material could be sent to local landfills (Subtitle D or Resource Conservation and Recovery Act Subtitle C), the disposal cost for these bulk materials would range from $0.3 billion to $1 billion. Clearly, the cost difference is substantial.

Process and Potential Mechanisms

The License Termination Rule 10 CFR 20, Subpart E (10 CFR 20.1401-1406), which was published in July 1997 (*Federal Register,* Vol. 62, No. 139, 39058–39095) and became applicable to all decommissioning projects in August 1998, sets a total effective dose equivalent (TEDE) limit of 25 millirems per year (0.25 millisieverts per year) to an average member of the critical group for unrestricted release of a decommissioned site. It also requires the application of the as-low-as-reasonably-achievable (ALARA) principle. (It should be noted that the NRC regulations also require reactor licensees to submit postshutdown decommissioning activities reports and license termination plans to support the decommissioning of nuclear power facilities.)

Essentially, the termination of a reactor operating license under the provisions of 10 CFR 20, Subpart E, is permitted when trace levels of licensed radioactive materials remain provided that the residual radioactivity does not result in a calculated TEDE exceeding 25 mrem/year. Thus, it is permissible to terminate the license for the site with decontaminated structures intact. However, under existing regulations, the release of debris from these structures prior to license termination with these same residual levels of radioactivity is not permitted.

It is the requirement under 10 CFR 20, Subpart K, to demonstrate the absence of licensed material that necessitates that some mechanism be found for the release of such materials.

There are only two potential mechanisms under the current circumstances:

- 10 CFR 20.2002 submission.
- License amendment submission.

10 CFR 20.2002 Submission

The regulatory requirements in 10 CFR 20, Subpart K, 20.2001, state that licensed radioactive material can be disposed of only through (i) transfer to an authorized recipient; (ii) decay in storage; (iii) release in effluents within the limits in 20.1301; or (iv) as authorized under 20.2002, 20.2003, 20.2004, or 20.2005. Subpart K does not provide a regulatory basis for demonstrating the absence of licensed radioactive materials when they could potentially exist.

Because there is no regulatory basis for demonstrating the absence of licensed radioactive materials, the NRC has provided guidance on how hard to look for both surface and bulk material contamination in items and material from restricted areas to be released as clean. However, this guidance was not developed for disposal of demolition debris during a decommissioning project. Furthermore, if this guidance were used, a licensee would always be subject to a third party using more sensitive instrumentation and identifying residual radioactivity on or in materials that had been released from the site. This would result in a violation of 10 CFR 20.2001.

In summary, while the 20.2002 submissions have been used for releasing small quantities of materials from operating reactors, they have not been used in general for the dispositioning of bulk material from decommissioning.

Under 20.2002, the material is still classified as radioactive material, which essentially excludes the potential use of a local landfill disposal if there are applicable restrictions at the landfill. The guidance for 20.2002 submissions is available in NUREG-1101 (published in 1986) and the past submissions to NRC by nuclear utilities pursuant to 10 CFR 20.2002 or 10 CFR 20.302.

and the U.S. Department of Energy, have remained on-again/off-again.

In 1999, the NRC embarked on an enhanced rulemaking effort for the control of solid materials. A number of stakeholder meetings were held around the country and at the NRC headquarters. While the nuclear industry and the professional societies were in favor of establishing such a rule, the NRC experienced intense opposition from certain public groups. The metal and concrete industries were also opposed to the rulemaking because of concerns about recycling material that may have residual radioactivity. In August 2000, the NRC turned to NAS for a study of the issue and recommendations on alternatives for controlling the release of solid materials. The NAS/National Research Council established a committee that studied the issue, solicited input from various stakeholder groups, and issued a report in March 2002.

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License Amendment Submission

A license amendment is another potential approach, consisting of a request to the NRC for license amendment that will essentially establish the site-specific release criteria for solid waste materials from the site, similar to the established limits for gas and liquid releases following a methodology like that of the Offsite Dose Calculation Manual. The NRC position on this is unclear.

Neither of the afore-mentioned two mechanisms is available in practice on a generic basis for a decommissioning project. Given the intensity of political and public reaction to the issue of release of solid materials, it is not expected that such mechanisms will resolve this issue.

Historical Perspectives and Developments in Release Criteria

The issue of defining some level at which the residual radioactivity can be considered as "trivial," and hence be subject to no further regulation, has been around since the 1980s. The NRC efforts culminated in the Below Regulatory Concern (BRC) policy of 1990, which was short-lived because of the immense controversy it generated. The U.S. Congress intervened in 1992 and revoked BRC, after the NRC had suspended the policy on its own.

Consensus on the issue has continued to be elusive, and efforts at the NRC and other federal agencies and departments, such as the U.S. Environmental Protection Agency

Since the publication of the NAS recommendations, the NRC has been deliberating on the future direction of regulatory efforts in this area.

In practice, the NRC licensees of nuclear power reactors have performed free release of materials under the "no detectable" concept. For solid items, this requirement had the licensees survey all accessible areas with a hand-held small-area Geiger-Mueller detector or equivalent in low-background environments. A minimum detectable count rate (MDCR) would be calculated, and any detected counts above the MDCR would be considered unacceptable for release. However, this process is not efficient for processing bulk materials.

Past clearance methodologies for solid materials and the release of radiologically contaminated sites have relied primarily on the use of surficial contamination guidelines given in *Regulatory Guide 1.86.* This guide provides a Table of Acceptable Surface Contamination Levels for various radionuclides, including natural and enriched uranium, transuranics, and fission products. The guide does not give volumetric contamination guidelines. The surface contamination levels are stated in terms of measurable radioactivity levels, but these values are not dose-based. The same basis levels are included in the *NRC Policy and Guidance Directive FC 83-23* (published in 1983). Surficial contamination guidelines have been used in the past for license termination of NRC licenses as well as in DOE projects. For beta-gamma emitters (except strontium-90 and others noted in Table 1 of *Regulatory*

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Guide 1.86), the acceptable average surface contamination level is 5000 dpm/100 cm^2. As mentioned earlier, the recent NRC efforts in rulemaking for the release of solid materials at licensed facilities were initiated with the publication of an issues paper in the *Federal Register* on June 30, 1999 (Vol. 64, No. 125, 35090–35100). As a part of the scoping process and to solicit public input, the NRC conducted four public workshops in San Francisco; Atlanta; Rockville, Md.; and Chicago between September and December 1999. Subsequently, several meetings were held at NRC headquarters. The NRC also published a comprehensive draft regulatory report, NUREG-1640 (draft published in March 1999), which was a culmination of efforts in this area over the past several years. It systematically covers both surficial as well as volumetric guidelines. However, as the process stalled, the NRC turned to NAS for recommendations.

One of the most important and related new regulatory developments in the decommissioning area is the publication of the License Termination Rule in 1997. It sets a dose limit of 25 mrem/year to an average member of the critical group for unrestricted release of a decommissioned site (10 CFR 20.1402). The methodology for compliance with the rule is a site-specific pathways analysis and the Final Status Survey of the site under MARSSIM (NUREG-1575, published in December 1997). For decommissioning projects, it is a potential option for the licensees to decontaminate the structures as necessary and include them in the Final Status Survey. Once the site license is terminated, the structures can be left intact or demolished.

Other developments have also taken place at the national and international level. The American National Standards Institute (ANSI) published a standard (developed by the Health Physics Society), ANSI/HPS N13.12 in October 1999, which provides both surface and volumetric radioactivity standards for clearance of equipment, materials, and facilities. The standard uses 1 mrem/year as the dose criterion, and the surficial levels are comparable to past practices. This standard is not accepted or endorsed by any regulatory agency as yet.

The DOE has also initiated efforts to establish their criteria in the area of materials release through a publication of a notice of intent in the *Federal Register* on October 12, 2000 (Vol. 65, No. 198, 60653). DOE Order 5400.5 is being amended with additional chapters that cover the issues of release of materials and property with residual radioactive contamination.

On the international scene, the International Atomic Energy Agency (IAEA) and the European Commission (EC) have established an essentially dose-based criterion of 1 mrem/year (10 μSv/year), even though the derived mass- and surface-specific levels may vary in different countries. Some relevant documents are IAEA-TECDOC-855 (published in 1996); Safety Series No. 111-P-1.1 (published in 1992); Safety Series No. 89 (published in 1988); and the EC's Radiation Protection 122 (published in 2001), Radiation Protection 113 (published in 2000), and Radiation Protection 89 (published in 1998). The IAEA uses the concept of "exclusion," "exemption," and "clearance." The amount of activity related to 1 mrem/year is considered "negligible radioactivity," and it is taken as the criterion for clearance. By contrast, the NRC guidance does not define a dose level for clearance.

INCONSISTENCIES

There are many inconsistencies in the approaches previously mentioned. The values derived from draft NUREG-1640 differ significantly from EC and IAEA values. For examples, for Co-60 (and the dose criterion of 1 mrem/year), the EC value for clearance of all metals is 1 becquerel per gram (0.6 Bq/g in Germany); in NUREG-1640 it is 0.04 Bq/g, which is 25 times more restrictive. Similarly, a comparison with IAEA values for Co-60 for all materials shows that the draft NUREG-1640 value is more than 10 times more restrictive (0.039 Bq/g as compared to 0.3 Bq/g from IAEA).

While the EC standard is based on the 1 mrem/year (10 μSv) criterion, the NRC has not defined this dose level for clearance. The draft NUREG-1640 gives dose factors in terms of μSv/year per Bq/g and μSv/year per Bq/cm^2 but does not specify a dose level.

For surficial guidelines also, there are differences between draft NUREG-1640 and Reg. Guide 1.86. For example, for Co-60, it provides a much more restrictive value of 280 dpm/100 cm^2, as compared to a value of 5000 dpm/100 cm^2 in the guide. The comparable value in the ANSI/HPS N13.12 standard is 6000 dpm/100 cm^2.

It is clear that, nationally and internationally, there are differences among the release criteria (as well as the proposed criteria). Given that international commerce involves millions of tons of steel in imports and exports, differences in standards between nations could lead to problems in the recycling and reuse of the materials. In developing a program for the release of equipment, recyclable metal, and concrete from a decommissioning project, these regulatory developments must now be taken into account. Even for the disposal case, which is the focus of this article, there are differences in the derived values.

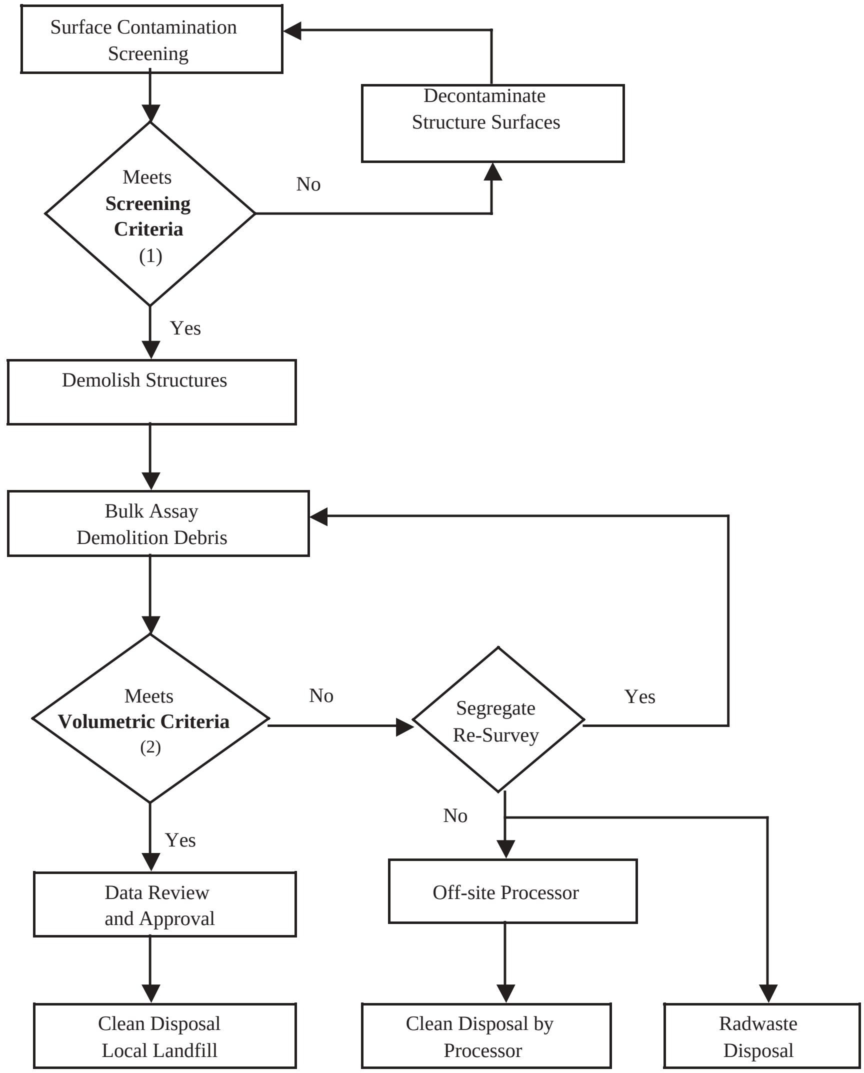
CURRENT INDUSTRY ALTERNATIVES

Following are the current practical alternatives for bulk materials:

1. Treating bulk materials as radioactive waste.
2. Processing under available state-licensed programs.

The current cost for LLW disposal can range from $100–$500 per cubic foot. The only three facilities in the country that accept LLW are Barnwell, S.C.; Hanford, Wash.; and Envirocare of Utah. The Hanford site restricts waste acceptance to material from only the Northwest and Rocky Mountain Compacts. Most of the LLW from the nation's nuclear power plants ends up at the Barnwell site, where the average cost in year 2000 was $235/ft^3. It should also be noted that access to the Barnwell disposal site has had its variations in the past decade, with access restricted to certain states at times and at other times with big surcharges imposed for out-of-compact waste. In addition, South Carolina has switched compacts, and access to Barnwell is going to be restricted in the future, with phase-out of all noncompact waste by 2008. The Envirocare site has license restrictions on what types of waste it can accept. It also presents a transportation cost issue, because most reactors are located in the eastern and midwestern part of the country. If bulk materials from decommissioning are treated as radioactive waste, the cost associated with transportation and disposal will be prohibitive for most decommissioning projects.

One industry alternative that is currently available is the "Green Is Clean" program in Tennessee, which is an NRC Agreement State. However, processing of materials through such a program still leads to substantial costs in transportation and disposal.



(1) ANSI/HPS N13.12-based screening criteria.
(2) Site-specific volumetric criteria derived based on 1 mrem/yr dose limit.

Fig. 1. A proposed approach to flow of bulk materials from decommissioning.

A Proposed Approach to Flow of Bulk Materials

From experience so far with these issues, we gather that it may be necessary to separate the issue of recycle from the issue of disposal of bulk materials because of the inherent difference between the two. Disposal provides a permanent removal of these materials from society. Recycle, on the other hand, allows material contact with society on a continued basis. This is no reflection that material, under certain guidelines, cannot be recycled safely, but a recognition that according to experience so far, the public is unlikely to accept recycling of the material with potential residual radioactivity.

Focusing on the disposal option, as a part of the work of the American Nuclear Society (ANS) Special Committee on Site Cleanup and Restoration Standards (SCRS), we have previously presented at ANS, Waste Management, and Electric Power Research Institute (EPRI) meetings a proposed flow schematic diagram for the bulk materials from decommissioning. This diagram is shown in Fig. 1.

The metal and concrete industries *are opposed to the NRC rulemaking because of concerns about recycling material that may have residual radioactivity.*

As a first step, a detailed surface radiological contamination survey of floors, walls, and ceilings will be performed. The results of the contamination survey will be compared against the selected screening criteria. A quality control team would check the results of the survey team to verify the results. If the survey results do not meet the screening criteria for certain areas, these areas will be decontaminated. If the survey results meet the criteria and are verified by the quality assurance team and are reviewed and approved by the management, the buildings will be demolished. The debris, cut to a size determined by the requirements of the bulk monitoring system, will be loaded into roll-off containers. Each roll-off container could contain several thousands of pounds of demolition debris. The bulk material will be processed through the bulk monitoring system, where gamma-ray spectroscopy detectors will be used to determine if any radioactive material of plant origin exists.

The bulk assay monitoring detectors will be set at volumetric contamination limits that are determined on a site-specific basis through the pathways analysis and an individual dose limit of 1 mrem/year. Such volumetric levels will have to be approved by the NRC for a given site. All debris found to be clean will be released for disposal and shipped to a local industrial landfill licensed by the state.

If the batch being processed does not meet the volumetric criteria, it can be segregated and resurveyed and the portions meeting the criteria put through the bulk assay system. For the material failing the resurvey, there are two options: Either treat it as radioactive waste and ship it to an LLW disposal facility or send it to a commercial processor for further processing and disposal.

The purpose of such a system will be that no detectable radiological contamination of plant origin is released. However, the necessary key steps are the screening criteria and the volumetric criteria. The screening levels will be those specified in ANSI/HPS N13.12. Under the current guidelines, *Regulatory Guide 1.86* provides the screening criteria. These levels are generally very close for certain radionuclides. The second and more crucial criteria are the volumetric criteria. This will be dose-based on the 1 mrem/year individual dose limit. From a practical standpoint, the key elements of such a flow process will be the determination of site-specific concentration levels for various radionuclides of interest and a bulk assay system to measure them. The concentration levels will be determined using pathways analysis methods and conservative assumptions for disposal on a site-specific basis, as mentioned earlier. Such levels will likely be in the range of a few picocuries per gram or a fraction of a picocurie per gram. For comparison purposes only, it should be noted that naturally occurring radioactive material (NORM), which is regulated by the states, has higher limits, e.g., 50 pCi/g for radium-226 in some states. The levels for the technologically enhanced NORM (TENORM) are also much higher.

The overall message of such a flow process is that treating bulk materials as LLW should be the last resort, not the first option. The system is still equally protective of public health and safety, but it provides a cost-effective way for the disposition of these materials, thus lowering the decommissioning costs substantially. It is also cognizant of environmental stewardship through preservation of the radioactive waste disposal capacity in the country.

The costs related to the disposal *of bulk materials as radioactive waste or processing such materials through special options are a burden on decommissioning projects that does not need to be there.*

BEYOND THE NAS RECOMMENDATIONS

Coming back to the NRC efforts, the recent NAS report generally concludes that "since the current case-by-case approach seems to be working, there is not a strong, unified impetus for change." In developing its recommendations, the committee states that it was guided by two compelling findings:

1. The current approach to clearance is workable and is sufficiently protective of the public health that it does not need immediate revamping.
2. Broad stakeholder involvement and participation in the NRC's decision-making process on the range of alternative approaches is critical as the NRC moves forward.

The committee has listed seven recommendations that can be summarized:

1. The NRC should devise a new decision framework that would develop, analyze, and evaluate a broader range of alternative approaches.
2. The NRC decision-making process on the range of alternatives should be integrated with a broad-based stakeholder participatory decision-making process.
3. The NRC should adopt an overarching policy statement describing the principles governing management and disposition of slightly radioactive solid material.
4. While considering either clearance or conditional clear-

***Given the fact that international** commerce involves millions of tons of steel in imports and exports, differences in standards between nations could lead to problems in the recycling and reuse of the materials.*

ance, a dose-based standard should be employed as the primary standard.
5. An individual dose standard of 1 mrem/year provides a reasonable starting point.
6. For a dose-based alternative approach, the NRC should use the conceptual framework of draft NUREG-1640.
7. The NRC should continue to review, assess, and participate in the ongoing international efforts in this area.

Building Consensus

From the collective experience so far, we can see that the clearance issue remains controversial. A substantial consensus among stakeholders is necessary to move the process forward. Even though the impetus for change may have diminished because of the recent surge in relicensing of reactors, the issue remains important, has immense consequences for overall decommissioning cost, and needs to be resolved to be consistent with national and international developments in this area. The key points in building a consensus and moving the process forward are as follows:

- Interagency effort at the federal level.
- One national regulatory standard.
- Full stakeholder involvement.
- Trust built with public groups.
- Separate recycling issues from disposal issues.
- Understanding that consensus is more achievable on disposal of bulk materials.
- Cost-benefit assessment of various approaches.
- Dose-based standards.
- Consistency with standards that are already available (ANSI/HPS N13.12).
- Consistency with international standards.
- 1 mrem/year as a reasonable basis for consensus.
- Revision of overly conservative assumptions in the analyses in draft NUREG-1640.
- Explanations to stakeholder public groups about the following: how low 1 mrem/year really is (approximately 0.3 percent of the average background exposure to an individual in the United States), the international concept of "trivial dose," and the meaning of "no adverse impact" on public health and safety.
- Comparison of NORM/TENORM levels to those expected from application of dose-based standards for the disposal of bulk materials from decommissioning.
- Derived levels based on dose limit, risk assessment methodology, and the disposal option.
- Environmental stewardship.

A Burden That Does Not Need to Be There

The cost of disposition of bulk materials from decommissioning is a substantial part of the overall decommissioning cost, in the range of 10–20 percent under the current options. Considering that these materials have only residual or no radioactivity, it is not an issue of radiological risk. Rather, it is an issue of a regulatory void. The costs related to the disposal of bulk materials as radioactive waste or to processing such materials through special options are a burden on decommissioning projects that does not need to be there.

While the NRC efforts of the past four years have made some progress on the issue, it appears that an approved methodology will not be forthcoming in the near future.

An individual dose criterion of 1 mrem/year (10 μSv/year) offers a reasonable basis for deriving site-specific volumetric clearance levels. This is also a criterion that is scientifically and internationally accepted for such application. Given that recycle and disposal are inherently different, and given the public's fear of recycling potential radioactivity, the rulemaking process could separate recycle and disposal options.

The ANSI/HPS standard N13.12 is an existing national standard that the NRC could consider for adoption. The National Technology Transfer and Advancement Act of 1995 requires federal agencies to use technical standards that are developed or adopted by voluntary consensus standard bodies unless the use of such a standard is inconsistent with applicable law or otherwise is impractical.

For the process to succeed, the NRC will also need full stakeholder involvement and will need to build consensus for the process. Because one national standard, rather than multiple standards, is desirable, interagency cooperation and agreement are also necessary.

(*Note:* Since this article was prepared, the NRC has restarted the rulemaking effort.) ■

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