IMPACT OF LACK OF CONSISTENT FREE RELEASE STANDARDS ON DECOMMISSIONING PROJECTS AND COSTS

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ABSTRACT

While the Nuclear Regulatory Commission has had specific and dose-based standards for the release of liquids and gases for a long time, there are no regulatory mechanisms in place for the release of solid bulk materials from a nuclear power plant. Even though free releases of small quantities of solid materials continue under existing guidelines from the operating plants, the regulatory void creates major difficulties for the bulk materials that result from the decommissioning of a nuclear site.

Decommissioning of a commercial nuclear power plant generates large quantities of solid bulk materials such as concrete, metal, and demolition debris. Disposition of such materials has a large impact on the overall decommissioning cost. Yet, there are no clear and cost-effective alternatives for the disposal of these materials from a regulatory perspective.

This paper discusses the methodologies for clearance of solid materials[1], their applicability to the disposition of bulk materials, and the impact of lack of consistent free release standards on the decommissioning projects and costs.

INTRODUCTION

Until about four years ago, a number of the currently operating plants were slated for decommissioning. The consolidation that occurred in the nuclear industry in the past three years has led to a reemergence of nuclear power and most reactors that were slated for decommissioning earlier are now being prepared for license extension. Nevertheless, the nuclear community in the United States, industry and the government complex, has substantial experience in decommissioning as more than seventy test, demonstration and power reactors have been decommissioned since the 1960s. Major commercial power reactor decommissioning projects that are currently underway include Maine Yankee, Connecticut Yankee, San Onofre 1, Rancho Seco, Millstone 1, and Big Rock Point. Eventually all reactors, including those whose licensees are being extended, will undergo decommissioning after they have outlived their design life or they are shutdown for economic or political reasons. 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 free release criteria have a significant impact on the overall decommissioning cost.

The regulatory framework applicable to the issue of release of solid materials is in a transition phase. While in the past, Regulatory Guide 1.86 (1) has formed the basis for clean up levels, the Nuclear Regulatory Commission (NRC) is currently in the process of developing dose-based criteria that will be applicable to releasing solid materials with residual radioactive contamination.

It should be noted that removal of the reactor vessel, the internals, and other contaminated equipment accounts for over 99% of the radioactivity. However, the clean up phase of decommissioning has to deal with radioactivity remaining on the plant structures and at the plant site. This can be a substantial part of the overall decommissioning cost and has the largest uncertainty associated with it.

This paper focuses on the impact that the free release standards or the lack thereof have on the decommissioning projects and their costs.

PAYING FOR DECOMMISSIONING

The nuclear utilities are required to accumulate decommissioning funds to meet the minimum requirements of 10 CFR 50.75 (b) and (c), which are $164 million for a PWR and $211 million (in year 2000 dollars), for a BWR. In general however, after updating for escalation of labor, low-level waste disposal, and the energy needs for decommissioning, the decommissioning costs are about $400 million for a full size reactor. While the costs of radioactive disposal and labor continue to increase, the advances in technologies lower the decommissioning costs.

Of the estimated cost of approximately $40 billion for the nation's nuclear power plants, about $30 billion had been collected in to the decommissioning funds by the end of year 2000. Changes in the fund requirements approved by U.S. Congress in 1992 have allowed the companies to accumulate funds more rapidly. These changes were primarily in two areas: lowering of the federal tax on the funds; and removing restrictions on where the funds could be invested. The net result has been that the decommissioning funds for almost all the reactors are adequate. The funds are monitored by the NRC and the state utility boards. With many of the reactors going for license extensions, these funds will continue to grow and it is expected that in general the decommissioning funding situation will remain adequate. However, it should be noted that the NRC requirements do not include the costs of dismantling of structures that are not radioactive or the cost of site restoration. Yet many of the decommissioning projects have to contend with such costs and generally the companies want to restore the decommissioned 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.

THE PROCESS AND POTENTIAL MECHANISMS

The License Termination Rule, 10 CFR 20 Subpart E (10 CFR 20.1401-1406), which was published in July 1997 (2) and became applicable to all decommissioning projects in August

1998, sets a total effective dose equivalent (TEDE) limit of 25 mrem/y (0.25 mSv/y) to an average member of the critical group for unrestricted release of a decommissioned site. It also requires the application of ALARA. It should be noted that the NRC regulations also require reactor licensees to submit Post-shutdown 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 with trace levels of licensed radioactive materials remaining providing that the residual radioactivity does not result in a calculated TEDE exceeding 25 mrem per year. Thus, it is possible to terminate the license for the site with decontaminated structures intact. However, release of debris from these structures prior to license termination with these same residual levels of radioactivity is not permitted under existing regulations.

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:

A. 10 CFR 20.2002 submission
B. License amendment submission.

10 CFR 20, Subpart K, 20.2001, requires that licensed radioactive material be disposed of only through (1) transfer to an authorized recipient, (2) decay in storage, (3) release in effluents within the limits in 20.1301, or (4) 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.

Since 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 for items and material to be released from restricted areas as clean. However, this guidance was not developed for disposal of demolition debris during a decommissioning project. Furthermore, if this guidance is used, a licensee is always 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, generally for on-site disposal, these have not been used for a decommissioning project. Under the 20.2002, the material is still classified as radioactive material, which essentially excludes the potential use of the local landfill disposal. The guidance for 20.2002 submissions is available in NUREG-1101 (3), other published guidance from the NRC (4), and the past submissions to NRC by nuclear utilities pursuant to 10 CFR 20.2002 or 10 CFR 20.302.

A license amendment is another potential alternate approach which will consist of a request to 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 similar to the ODCM. Such a request has not been tried yet and the NRC position on this is unclear.

Thus, neither of the two mechanisms has been approved 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 a successful application of such mechanisms would occur in near future.

POTENTIAL APPROACHES FOR BULK MATERIALS

Demolition of structures and disposal of concrete rubble and other building materials are among the final steps in restoring the site to greenfield conditions. There are basically three approaches for dealing with of concrete rubble and other bulk materials from demolition:

1. License termination with structures intact,
2. Demolition followed by license termination,
3. Demolition and disposal followed by license termination.

The first approach will involve removal of licensed radioactive materials from the existing structures to residual radioactivity levels acceptable for termination of the license. Verification of achieving these residual radioactivity levels would require conducting Final Status Survey (FSS) under MARSSIM (5) of the remaining structures as well as the site environs. After license termination by NRC, the site would be returned to greenfield conditions by demolishing the remaining structures and disposal of the concrete rubble in a local landfill. The disadvantages are the costs associated with the survey of structures, which can run into several millions of dollars for a typical reactor site. From regulatory verification purposes also, it is lot more difficult because of the presence of buildings and the large quantity of materials at the site.

The second approach is similar to license termination with structures intact. Removal of licensed radioactive materials from existing structures to residual radioactivity levels acceptable for license termination would still be performed. However, prior to performing the FSS, the remaining structures would be demolished and the concrete rubble left on site. The FSS would then be performed on the site environs. After license termination, the concrete rubble could be used as construction fill or disposed of in a local landfill facility. While this meets NRC requirements and public health and safety goals, the disadvantages are that the debris is not stabilized in the long-term context. Redevelopment of the site for other uses will also mean that debris may have to be removed at some later date and relocated to another location on-site or off-site.

The third approach would also involve removal of licensed radioactive materials from the existing structures to residual radioactivity levels acceptable for termination of the license. However, prior to performing the FSS, the remaining structures would be demolished and the concrete rubble cleared from the site under some NRC criteria (generic or site-specific) and disposed of in a local landfill facility. After removal of all demolition debris, the FSS would then be performed on the site environs, the license terminated by the NRC, and the site released for unrestricted future use.

FREE RELEASE THEN AND NOW

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. The process was open to error by several avenues: it addressed surface areas only; the process was open to technician survey error; detector efficiency variance due to changes in geometry; varying redionuclide mixes; variation in background levels; and the items themselves may have inaccessible areas making the process nonviable.

In the past, clearance methodologies for solid materials and the release of radilogically contaminated sites have relied primarily on the use of surficial contamination guidelines given in Regulatory Guide 1.86 (1). This guide, which was developed by the Atomic Energy Commission in 1974, 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 also included in the NRC Policy and Guidance Directive FC 83-23 (6). Surficial contamination guidelines have been used for license termination not only for NRC licenses but also in Department of Energy (DOE) projects (7). For Beta-Gamma emitters (except Sr-90 and others noted in table 1 of the Regulatory Guide 1.86), the acceptable average surface contamination level is 5000 dpm/ 100 cm^2.

More recently, the NRC initiated the rule making process for the release of solid materials at licensed facilities with the publication of an issues paper in Federal Register (8) on June 30, 1999. As a part of the scoping process and to solicit public input, the NRC conducted four public workshops in San Francisco, Atlanta, Rockville and Chicago during the time period from September 1999 to December 1999. The NRC also made available a comprehensive draft regulatory guide, NUREG-1640 (9), in early 1999, which was a culmination of efforts in this area over the past several year. It systematically defines the methodology for clearance and covers both surficial as well as the volumetric guidelines.

However, several groups at the NRC workshops as well as through written comments strongly opposed the establishment of a clearance rule. The NRC deferred the issue to National Academy of Sciences (NAS) for a study. At the present the NAS recommendations are pending on the issue.

DEVELOPMENTS IN THE RELEASE CRITERIA

The regulatory framework applicable to the release of solid materials is in a transition phase. As mentioned earlier, free release in the past relied primarily on the use of surficial contamination guidelines given in Regulatory Guide 1.86.

The NRC is in the process of developing a methodology for the clearance of solids based on pathways analyses. The input that NRC received from the metal and concrete industries has been strongly opposed to any attempts at establishing recycle standards. Some public groups also objected strongly to the rulemaking effort. The NRC has asked the National Academy of Sciences to study the alternatives. It is clear from the process so far that the issue of recycle of materials needs to be separated from the issue of disposal of such materials.

A number of other related regulatory developments have taken place in the past few years that are relevant to the current subject. These developments have significantly altered the criteria for license termination after the decommissioning of a site and may significantly change the criteria for releasing bulk solid materials during decommissioning. The most important of the new regulatory developments is the publication of the License Termination Rule in 1997 (10). It sets a dose limit of 25 mrem/y 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 another important development. The compliance now must be demonstrated through pathways analysis modeling and a Final Status Survey of the site under MARSSIM. The NRC has completed a number of guidance documents in this area including the NUREG-1727 (Standard Review Plan) (11), NUREG- 1700 (12), Regulatory Guides 1.184 (13) and 1.185 (14); and the DandD screening code. For decommissioning projects, it is a possible option for the licensees to decontaminate 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, ANSI N13.12 (15) in October 1999, which provides both surface and volumetric radioactivity standards for clearance of equipment, materials, and facilities. The standard uses 1 mrem/y as the dose criteria and the surficial levels are comparable to past practices. Nevertheless 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 notice of intent in the Federal Register on October 12, 2000 (16). The 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, International Atomic Energy Agency (IAEA) and the European Commission (EC) have established an essentially dose based criteria of 1 mrem/y (10 μSv/y), even though the derived mass-specific and surface-specific levels may vary in different countries. Some relevant documents are IAEA-TECDOC-855 (17), Safety Series No. 89 (18), and European Commission Radiation Protection 89 (19). The IAEA uses the concept of "exclusion", "exemption" and "clearance". The amount of activity related to1 mrem/y 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.

However there are inconsistencies in these approaches. The values derived from draft NUREG-1640 differ significantly from EC and IAEA values. For examples, for Co-60 (and the dose criteria of 1 mrem/y), the EC value for clearance of all metals is 1 Bq/g (0.6 Bq/g in Germany), it is 0.04 Bq/g in NUREG-1640, which is 25 times more restrictive. Similarly, a comparison with IAEA values for Co-60 for all materials shows that the NUREG-1640 value is approximately 10 times more restrictive (0.039 Bq/g as compared to 0.3 Bq/g from IAEA).

For surficial guidelines, NUREG-1640 also compares inconsistently with 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 N13.12 standard is 6000 dpm/100 cm^2.

From the discussion above it is clear that while the European standard is based on the 1 mrem/y (10 ΠSv/y) criteria, the NRC, by contrast, has not defined this dose level for clearance. The NUREG 1640 gives dose factors in terms of ΠSv/y per Bq/g and ΠSv/y per Bq/ cm^2 but does not specify a dose level.

It is clear that nationally and internationally, there are inconsistencies in the release criteria (and the proposed criteria). Given the fact that international commerce involves millions of tons of steel in imports and exports, inconsistencies in standards between the nations could lead to major problems in the recycle and reuse of 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 paper, there are inconsistencies in the derived values.

The clearance levels for bulk materials have a direct and significant impact on the overall decommissioning costs because the volume of decommissioning waste will be essentially determined by these levels. It is somewhat analogous to the relationship of the cleanup criteria to the cleanup cost. In the site cleanup cost experience in the DOE complex, it has been substantiated in a number of studies that the costs rise steeply with lower cleanup levels. There is no rationale for treating the bulk materials, primarily demolition debris, as radioactive waste. Bulk material monitoring techniques are available and can ensure that material above the guidelines is not released. The need for a timely resolution of this issue is clear.

INDUSTRY ALTERNATIVES

The practical alternatives for the bulk materials consist of:

1. Treating bulk materials as radioactive waste
2. Processing under "Green Is Clean" program

The cost for low level radioactive waste (LLW) disposal can range from \$100-\$1000/ ft^3. The only three facilities that accept LLW are Barnwell, S.C., Hanford, WA, and Envirocare, UT. The Hanford site restricts waste acceptance only from its Northwest and Rocky Mountain

Compacts. Most of the LLW from 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 Barnwell disposal site has had its ups and downs in past decade with access restricted to certain states at times and at other times with huge surcharges were added for out of compact waste. In addition, South Carolina has also switched compacts in the past. Thus access to Barnwell is by no means guaranteed in future. The Envirocare site has license restrictions on what types of waste it can accept. It is also presents a transportation issue in terms of cost as most of the reactors are located in the east and midwest part of the country. However, even under the best case scenario, if bulk materials from decommissioning are treated as radioactive waste, the cost associated with transportation and disposal will be prohibitive for most decommissioning projects.

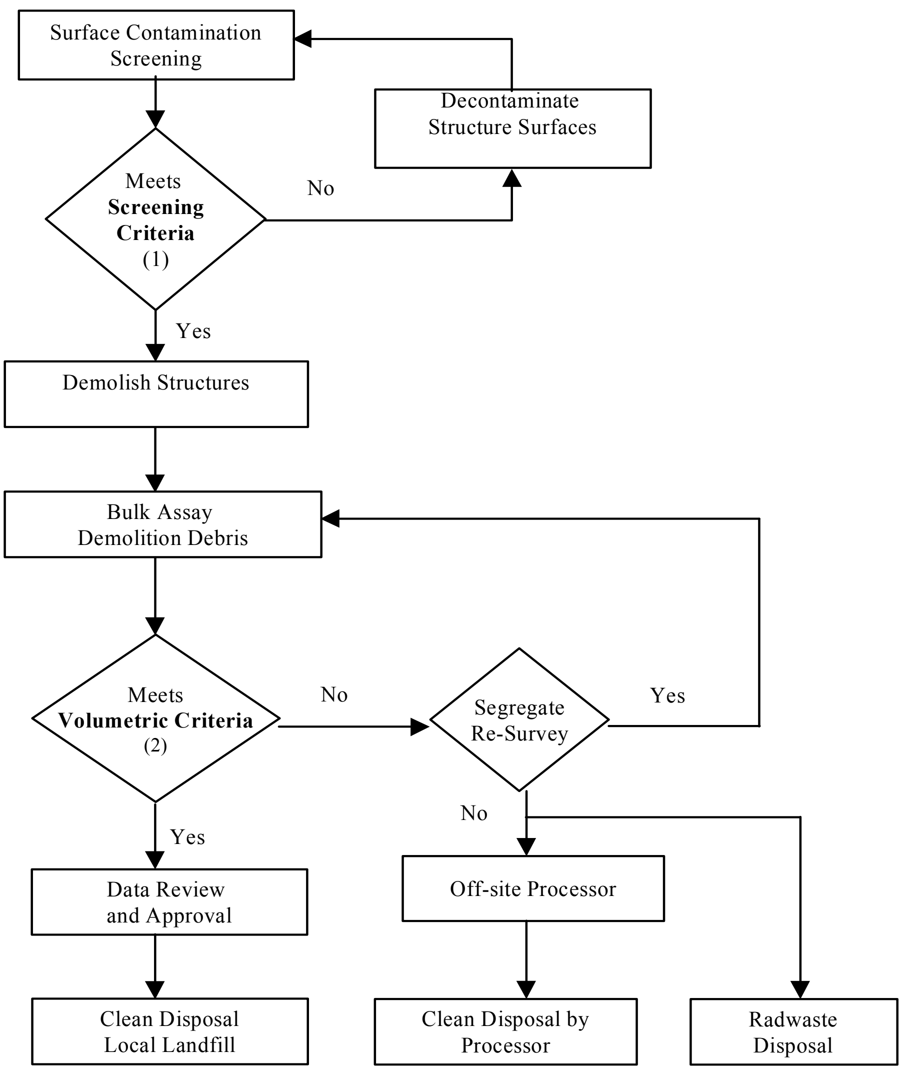
Another industry alternative that is currently available is the "Green Is Clean" (GIC) program run by Duratek in Tennessee, which is an agreement state. However, processing of materials through such a program still leads to substantial costs in transportation and disposal. For example, in the case of Big Rock Point, where a relatively small, 67 MWe BWR is being decommissioned, the cost differential between local disposal of bulk materials and processing through GIC was estimated in 1999 at over $ 23 million. This is a significant portion of the $ 270 million decommissioning budget (not including the spent fuel storage/ISFSI costs).

Considering that most of the bulk materials have little or no radioactivity, the disposal costs of bulk materials is a burden on the decommissioning projects that does not need to be there. It should also be noted that this is not an issue of radiological risk; it is instead an issue of regulatory void.

PROPOSED APPROACH TO FLOW OF BULK MATERIALS

A proposed flow schematic for the bulk materials from decommissioning is shown in Figure 1.

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 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 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 up to approximately 40,000 lbs. 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 existed.



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

Fig. 1: Proposed Flow of Bulk Materials from Decommissioning

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/y. Such volumetric levels will have to be approved by the NRC for that 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 re-surveyed and the portions meeting the criteria put through the bulk assay system. For the material failing the re-survey there are two options, either to treat it as radioactive waste and ship to a low level waste disposal facility or to send it to commercial processor for further processing and disposal.

The idea 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 N13.12. Under the present guidelines Reg. Guide 1.86 provides the screening criteria. These levels are generally very close for various radionuclides. The second and more crucial criteria are the volumetric criteria. This will be dose-based as in ANSI N13.12 i.e., based on the 1 mrem/y individual dose limit. From practical standpoint, the key elements of such a flow process will be the Minimum Detectable Activities (MDAs) and a Bulk Assay System to measure them. The MDA will be determined using pathways analysis methods and conservative assumptions for disposal on the site-specific basis, as mentioned earlier.

To process such large quantities of materials, it is necessary to design a system with release MDA in the range of a few pCi/g or a fraction of a pCi/g. Some systems on the market for truck monitoring purposes can be adapted for such use or custom made.

Such a flow process is feasible. As an example, a preliminary pathways analysis conducted at Big Rock Point site with conservative assumptions resulted in a MDA of 5 pCi / g for Co-60. Similarly, the MDAs for other radionuclides of interest can be calculated and the final levels for a mixture of radionuclides derived based on the unity rule i.e. sum of fractions remaining 1 or below. For comparison purposes only, it should be noted that Naturally Occurring Radioactive Material (NORM) which is regulated by the states has a lot higher limit; for example, 50 pCi/g in Michigan. It should also be noted that environmental release limits based on laboratory analysis of samples are generally so low that these are beyond the detection capability of current bulk assay and bulk processing systems.

Counting equipment will need to count large volumes of solid material to levels that will meet bulk release criteria. Such levels could be below 10 pCi / g for many of the radionuclides of interest in the decommissioning projects. The bulk assay system will need to be capable of measuring to such levels in quantities of say 40, 000 lbs. at a time. Given the current available technology, such monitoring equipment is feasible even though it may need to be custom fabricated.

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 the public health and safety but it provides for a cost-effective way of disposing of these materials thus lowering the decommissioning cost substantially. It is also cognizant of the environmental stewadship through preservation of the radioactive waste disposal capacity in the country.

CONCLUSIONS

At the present there are no consensus standards in the area of solid materials release and there is a regulatory void for the release of such materials in bulk quantities. While the NRC has undertaken a rule making effort for establishing a methodology for the clearance of solid materials, it is not clear if such a methodology will be approved anytime soon.

For decommissioning projects, which must deal with large quantities of clean or slightly contaminated demolition debris, there are few choices in the regulatory system. Considering that most of the bulk materials have little or no radioactivity, it is not an issue of radiological risk; it is instead an issue of regulatory void. The costs related to disposal of bulk materials as radioactive waste or processing such materials through special options is a burden on the decommissioning projects that does not need to be there.

The ANSI N13.12 standard offers the best option for consensus for establishing the surficial and volumetric criteria that can be applied at the decommissioning site. The ANSI standard is based on the dose criterion of 1 mrem/y. This is consistent with the international standards from IAEA and the European Community. Considering that the public dose limit is 100 mrem/y and the license termination dose limit is 25 mrem/y, the dose level criterion of 1 mrem/y or below is essentially trivial from the perspective of any public health risk. This is a reasonable standard and can go a long way in eliminating the unjustified costs in millions of dollars that will be spent by a decommissioning project in addressing the issue of bulk materials.

FOOTNOTES

[1] For the purpose of this paper, free release and clearance are used interchangeably. The focus of this paper is on the eventual disposal of such materials, not their recycle or reuse.

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