Revision of the Branch Technical Position on Concentration Averaging and Encapsulation - 12510

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ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) regulation governing low-level waste (LLW) disposal, "Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR Part 61, establishes a waste classification system based on the concentration of specific radionuclides contained in the waste. The regulation also states, at 10 CFR 61.55(a)(8), that, "the concentration of a radionuclide (in waste) may be averaged over the volume of the waste, or weight of the waste if the units are expressed as nanocuries per gram." The NRC's Branch Technical Position on Concentration Averaging and Encapsulation provides guidance on averaging radionuclide concentrations in waste under 10 CFR 61.55(a)(8) when classifying waste for disposal. In 2007, the NRC staff proposed to revise the Branch Technical Position on Concentration Averaging and Encapsulation. The Branch Technical Position on Concentration Averaging and Encapsulation is an NRC guidance document for averaging and classifying wastes under 10 CFR 61. The Branch Technical Position on Concentration Averaging and Encapsulation is used by nuclear power plants (NPPs) licensees and sealed source users, among others. In addition, three of the four U.S. LLW disposal facility operators are required to honor the Branch Technical Position on Concentration Averaging and Encapsulation as a licensing condition.

In 2010, the Commission directed the staff to develop guidance regarding large scale blending of similar homogenous waste types, as described in SECY-10-0043 as part of its Branch Technical Position on Concentration Averaging and Encapsulation revision. The Commission is improving the regulatory approach used in the Branch Technical Position on Concentration Averaging and Encapsulation by moving towards a making it more risk-informed and performance-based approach, which is more consistent with the agency's regulatory policies. Among the improvements to the Branch Technical Position on Concentration Averaging and Encapsulation are more risk-informed limits for the sizes of sealed sources for safe disposal. Using more realistic intruder exposure scenarios, the suggested limits for Class B and C waste disposal of sealed sources, particularly Cs-137 and Co-60, have been increased. These suggested changes, and others in the Branch Technical Position on Concentration Averaging and Encapsulation, if adopted by Agreement States, have the potential to eliminate numerous orphan sources (i.e., sources that currently have no disposal pathway) that are now being stored. Permanent disposal of these sources, rather than temporary storage, will help reduce safety and security risks. The revised Branch Technical Position on Concentration Averaging and Encapsulation has an alternative approach section which provides flexibility to generators and processors, while also ensuring that intruder protection will be maintained. Alternative approaches provide flexibility by allowing for consideration of likelihood of intrusion, the possibility of averaging over larger volumes and allowing for disposal of large activity sources. The revision has improved the organization of the Branch Technical Position on Concentration Averaging and Encapsulation, improved its clarity, better documented the bases for positions,

and made the positions more risk informed while also maintaining protection for intruder as required by 10 CFR Part 61.

INTRODUCTION

10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," provides licensing procedures, performance objectives, and technical requirements for the issuance of licenses for the land disposal of low-level radioactive waste (LLW). Four performance objectives, including protection of the general public from releases of radioactivity, protection of individuals against inadvertent intrusion, worker protection, and site stability define the overall level of safety to be achieved by disposal. A low-level radioactive waste disposal facility must be designed, operated, closed, and controlled after closure in a manner that provides reasonable assurance that these performance objectives will be met. In its evaluation of the second performance objective, protection of individuals against inadvertent intrusion, NRC assumes that, at some time after active institutional controls over the disposal site are removed an individual unknowingly intrudes onto the disposal site and interacts with the waste. To protect this hypothetical individual, NRC developed a waste classification system (10 CFR § 61.55) that requires greater control measures for waste with greater radionuclide concentrations.

Protection of the inadvertent intruder is provided in part by the waste classification concentration limits in 10 CFR § 61.55, which are designed to ensure that an inadvertent intruder is not exposed to unsafe levels of radiation. All LLW must be classified in accordance with the waste classification tables in 10 CFR § 61.55. Concentrations of radionuclides that are used to determine the waste classification may be averaged over the volume or weight of the waste, in accordance with 10 CFR § 61.55(a)(8).

The Branch Technical Position on Concentration Averaging and Encapsulation provides guidance for waste generators and processors classifying waste for disposal. The Branch Technical Position on Concentration Averaging and Encapsulation presents acceptable methods by which radionuclide concentrations in specific waste streams or mixtures of these waste streams may be averaged over the volume or mass of waste in a waste package. The Branch Technical Position on Concentration Averaging and Encapsulation provides guidance on complying with § 61.55(a)(8) as it applies to the classification of waste for disposal under 10 CFR Part 61. The NRC is revising the Branch Technical Position on Concentration Averaging and Encapsulation to improve its clarity; to update the position on LLW blending, as directed by the Commission; and to align the Branch Technical Position on Concentration Averaging and Encapsulation with the agency's direction of providing a risk-informed performance-based regulatory approach [1].

The U.S. Nuclear Regulatory Commission (NRC) regulations require that the waste class be identified for each disposal container in a shipment of radioactive waste to a licensed LLW land disposal facility. This information is reported on a shipping manifest as specified in Appendix G, 10 CFR Part 20, of NRC's regulations. Licensees shipping waste are required to certify that each waste package listed on the manifest is properly classified as Class A, B, or C in accordance with 10 CFR § 61.55. As the waste class increases from Class A to Class C, the potential hazard to an inadvertent intruder increases. This hazard is managed by more stringent disposal requirements for higher classes of waste. The Branch Technical Position on Concentration Averaging and Encapsulation addresses the classification of individual waste containers to help facilitate compliance with the Appendix G requirements. Guidance for

averaging across multiple waste containers is outside the scope of the Branch Technical Position on Concentration Averaging and Encapsulation.

Although Agreement States are required to adopt waste classification regulations that are essentially identical to the NRC's in 10 CFR § 61.55,[1] they may use averaging approaches different from those contained in the Branch Technical Position on Concentration Averaging and Encapsulation. Waste generators should therefore ensure that the disposal facility license conditions related to waste classification and averaging are met before shipping waste to a licensed disposal facility. Consultation with disposal facility operators and/or appropriate regulatory authorities may be needed. In many cases, shipments of LLW are routine and consultation would not be required. In some cases, such as shipments of blended ion exchange resins from multiple sources, there may need to be assurance that the disposal facility has determined that these types of waste are acceptable for disposal, and additional waste acceptance criteria may be specified for them. It is expected that Agreement States that either approve a change in equipment or procedures related to intentional blending during processing of LLW, also called large-scale blending, or that regulate the disposal of these types of blended wastes, would consult with one another to ensure that these types of wastes are acceptable for disposal.

In 2007 the NRC staff performed a strategic assessment of the NRC's regulatory program for LLW. The staff undertook this effort in recognition of significant new and emerging LLW disposal issues. The strategic assessment identified a need to update the Branch Technical Position on Concentration Averaging and Encapsulation. Revisions to the Branch Technical Position on Concentration Averaging and Encapsulation have the potential to increase the flexibility of disposal of certain types of LLW, particularly sealed sources and irradiated hardware. The strategic assessment stated that the staff will use risk-informed approaches and knowledge that were not available when the Branch Technical Position on Concentration Averaging and Encapsulation was developed and last updated (in 1995).

In SECY-10-0043, the staff provided the NRC Commission with an analysis of issues related to LLW blending. In the 1995 Branch Technical Position on Concentration Averaging and Encapsulation blending of LLW is constrained by the factor of 10 rule. In the Staff Requirements Memorandum (SRM) for SECY-10-0043 the Commission directed the staff to revise the blending position in the Branch Technical Position on Concentration Averaging and Encapsulation to be risk-informed and performance-based as part of the revision the staff proposed to make in its LLW strategic assessment (REF). Revising the Branch Technical Position on Concentration Averaging and Encapsulation aligns with the NRC's position of moving towards a risk-informed performance-based regulatory approach. The revised draft Branch Technical Position on Concentration Averaging and Encapsulation has taken a more risk-informed performance-based approach, and improved the clarity of the document and addressed LLW blending, consistent with the Commission direction to the staff.

The NRC believes in openness and transparency when conducting its regulatory responsibilities. The process of revising the Branch Technical Position on Concentration Averaging and Encapsulation follows the agency's openness policy. The NRC staff has continued to inform and involve stakeholders in the regulatory process. The staff has conducted two public workshops in DC (January 14, 2010 and February 24, 2011) and New Mexico

[1] 10 CFR § 61.55 is NRC compatibility category B. This category is for activities that have direct and significant transboundary implications.

(October 20, 2011), gathering comments from public stakeholders, industry and other government agencies. The NRC staff is revising based on public comments received and will publish the revised draft Branch Technical Position on Concentration Averaging and Encapsulation for public comments in the spring of 2011. The NRC will continue to keep the public informed and provide updates on the NRC website.

DISCUSSION

Need for Homogeneity Guidance

The 1995 Branch Technical Position on Concentration Averaging and Encapsulation does not contain specific guidance on quantifying the homogeneity of miscible wastes. Instead, the 1995 Branch Technical Position on Concentration Averaging and Encapsulation recommended a constraint on the range of radionuclide concentrations in the inputs to a waste mixture. This constraint became known as the "factor of 10 rule"[2]. The factor of 10 rule specified that radionuclide concentrations in a waste mixture should be averaged only if the radionuclide concentrations in the inputs *before mixing* are within a factor of 10 of the final radionuclide concentrations. Recently, the NRC staff proposed to eliminate this constraint because it is not performance-based; that is, it is based on the inputs to a process rather than the output [1].

In the corresponding Staff Requirements Memorandum (SRM-SECY-2010-0043), the Commission agreed with the staff's proposal to eliminate the factor of 10 rule and replace it with homogeneity guidance focused on final waste forms rather than inputs to waste mixing processes. Specifically, the Commission directed the staff to develop a clear standard for determining homogeneity and to evaluate homogeneity in the context of the volumes of waste an intruder could encounter in reasonably foreseeable inadvertent intruder exposure scenarios.

Industry has recently expressed interest in blending wastes with a wide range of radionuclide concentrations to create Class A waste. In response to this industry proposal, a stakeholder expressed the concern that an intruder could encounter pockets of waste with radionuclide concentrations equivalent to Class B or C concentrations within waste disposed of as Class A waste. Two factors limit this potential concern. One is that intruders who exhume a relatively large amount of waste (e.g., during construction of a dwelling) will mix waste as they exhume it, reducing the impact of any areas of elevated radionuclide concentration. The second is that intruders who exhume a relatively small amount of waste (e.g., during well drilling) and are therefore more susceptible to contacting areas of elevated concentration are somewhat protected by the limited activity in the small amount of waste exhumed.

To determine whether these factors are sufficient in limiting concerns about "hotspots" in miscible waste, the NRC staff considered a range of intrusion scenarios. Specifically, the staff estimated doses to hypothetical individuals living on sites on which either a relatively large or small amount of waste had been exhumed (e.g., to construct a dwelling or drill a well) and spread on the land surface. Although exhuming more waste typically leads to larger doses, an

[2] There are two "factor of 10" rules in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation. The one described here limits the differences in the average radionuclide concentrations in homogeneous waste types that are mixed and placed in a single container. This factor of 10 rule was eliminated in the current draft. The other "factor of 10 rule" in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation limits the differences in the concentrations of non-primary gamma emitters in individual items disposed of in a single container. This factor of 10 rule was retained in modified form in the current draft.

intruder exhuming many waste packages (e.g., an individual constructing a dwelling) will naturally homogenize waste over a relatively large volume, reducing the impact of any areas of elevated concentrations [2]. An intruder exhuming a relatively small volume of waste (e.g., a well driller) is more susceptible to encountering "hot spots" in the waste and averaging the exhumed waste over a much smaller volume.

Thus to determine whether any bounds are necessary on the heterogeneity of waste mixtures, the staff considered the dose to an individual living on land on which a relatively small amount of waste had been exhumed and spread on the land surface. Based on these analyses, the staff determined that, in some circumstances, bounds should be placed on the heterogeneity of waste mixtures to meet the 10 CFR 61.42 requirement to protect individuals from inadvertent intrusion.

Homogeneous Waste Types

The current draft of the Branch Technical Position on Concentration Averaging and Encapsulation retains the designation of "homogenous waste type" as introduced in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation. Homogeneous waste types are wastes that are assumed to be homogeneous for the purpose of waste classification. Homogeneous waste types include solidified or absorbed liquid, spent ion-exchange resins, filter media, evaporator bottom concentrates, ash, contaminated soil, and containerized dry active waste (DAW). Solidified liquid is considered a homogenous waste type because radionuclide concentrations are expected to be uniform at the time of disposal. Spent ion-exchange resins, filter media, evaporator bottom concentrates, ash, and contaminated soil are considered a homogenous waste type because they are flowable and miscible, and the radionuclides in these waste streams are expected to be uniformly distributed when exhumed under reasonably foreseeable intruder scenarios. DAW, which may be composed of a variety of miscellaneous materials, may be considered a homogeneous waste type for purposes of waste classification when placed in containers because it is expected to degrade to a more soil-like state in which it will be mixed if exhumed by an intruder within approximately 100 years. Even if waste is not completely mixed as it is exhumed and spread on the surface, intruder exposure to a homogenous waste type is expected to be further averaged by the natural movement of the intruder around the site.

Because of the low likelihood that an intruder exhuming a small amount of waste would encounter a hotspot in a waste that typically is expected to be homogeneous, the NRC staff does not believe that any benefits realized by making measurements for the purpose of quantifying the homogeneity of these wastes justify the additional dose incurred by workers making those measurements. Thus the NRC staff has recommended that these specific waste streams may be assumed to be homogeneous for the purposes of waste classification and that no tests be performed to demonstrate homogeneity of these wastes.

NRC staff expects that the classification of homogenous waste types will continue to be made based on the total inventory of each radionuclide in a waste container divided by the volume or mass of waste in the container, as appropriate for the particular radionuclide.

Wastes Intentionally Mixed During Processing (Large-Scale Blending)

The revised Branch Technical Position on Concentration Averaging and Encapsulation contains specific guidance regarding intentional blending of wastes with very different radionuclide concentrations during waste processing. This guidance was developed because (1) insufficiently blended waste could contain pockets with radionuclide concentrations more than an order of magnitude greater than the relevant class limits, and (2) processors engaging in large-scale blending of waste are expected to produce more blended waste than generators who blend waste incidentally. The first factor could increase risk to an intruder by increasing the consequences of intruder interaction with the waste, if the intruder happened to exhume a pocket with elevated radionuclide concentrations. The second factor could increase risk to an intruder by increasing the probability that an intruder constructing a dwelling or well (or otherwise disrupting the site) at a random location on site will interact with these pockets of waste.

For these reasons, the current draft Branch Technical Position on Concentration Averaging and Encapsulation recommends that processors who blend waste with concentrations of classification-controlling radionuclides that differ by more than a factor of 10 demonstrate that the blended waste is radiologically homogeneous. Specifically, the current draft Branch Technical Position on Concentration Averaging and Encapsulation proposes that processors demonstrate that no pocket of waste of 0.03 cubic meters (1 cubic foot) or more has a sum of fractions that exceeds the relevant classification limit by more than a factor of 10. The staff currently is developing a technical basis for the allowable frequency of such pockets, and intends to refine this guidance to indicate that processors should demonstrate that such pockets are unlikely.

The staff expects that this test typically will be applied to waste processes. That is, the staff expects that processors will demonstrate that their blending process thoroughly mixes waste and that demonstration will remain valid until a significant change is made in the process or the characteristics of the input waste streams. To demonstrate that the process results in a well-mixed product, it may be efficient for processors to conduct surveys while waste is mixed (e.g., if a survey can be performed on a pipe as waste is recirculated) or as it is sluiced into disposal containers. Alternately, processors may apply the test to individual containers. In any case, the NRC staff expects that, irrespective of any position in the Branch Technical Position on Concentration Averaging and Encapsulation, waste processors will need to demonstrate that their process results in well-mixed waste to have the necessary industrial process control.

Classification of Homogeneous Wastes

During development of the staff's position on waste blending (SECY-00043), stakeholders expressed the concern that blended waste could not be characterized well enough to demonstrate that it meets the appropriate classification limits. Although this concern was initially raised in the context of large-scale blending, uncertainty in waste classification is not unique to blended waste. The numerical uncertainty in waste classification is not addressed quantitatively in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation. However, the 1983 Branch Technical Position on Concentration Averaging and Encapsulation on waste classification indicates that, if small changes in a process could change the waste classification, a more robust process is needed to demonstrate that the waste meets the classification limits [3].

The proposed draft BPT recommends that waste classifiers quantify the main sources of uncertainty contributing to waste classifications. These sources of uncertainty may include uncertainty in scaling factors and spatial variability in radionuclide concentrations, among others. In addition, the draft BPT recommends that the average sum of fractions should not be within one standard error of one. If the underling measurements are normally distributed, or if sufficient measurements have been taken so that the mean is normally distributed, this demonstration would provide approximately an 85% confidence level that the true sum of fractions is below the relevant classification limit. Based on initial public comments, the staff is revisiting this guidance and expects revised guidance on the uncertainty waste classification calculations for homogeneous wastes to be included in the draft published for public comment in the spring of 2011.

Encapsulation of Sealed Sources and Other Solid LLWs

Encapsulation is the process of surrounding a radioactive item (such as a sealed source or a cartridge filter) in a binding matrix, in a container where the radioactivity remains in the original dimensions of the encapsulated item. Encapsulation can mitigate waste dispersion, provide shielding to limit external radiation doses to workers, and satisfy the stability requirement of 10 CFR § 61.56(b) and technical requirements for land disposal facilities of 10 CFR § 61.52(a).

Existing Encapsulation Guidance

For classifying encapsulated items using the Tables in 61.55, the 1995 Branch Technical Position on Concentration Averaging and Encapsulation allows the activity in the encapsulated item to be averaged over the volume or mass of the encapsulating media. The 1995 Branch Technical Position on Concentration Averaging and Encapsulation limits the amount of credit allowed for encapsulation, so that extreme measures are not taken solely for the purposes of lowering the classification of the waste. Four of the key limits are:

- The maximum encapsulating volume or mass is 0.2 m^3 or 500 kg
- Only a single item can be encapsulated in each package
- For non-gamma emitters, the maximum activity is set by the 61.55 classification limit for that nuclide, when averaged across the encapsulating media, and
- For primary gamma-emitting nuclides, the maximum activity is set in the Branch Technical Position on Concentration Averaging and Encapsulation.

The maximum activity of the primary gamma-emitting nuclides is detailed in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation, and the activity limits depend on the nuclide and the classification of the encapsulated package (Class A, B, or C). For example, for Cs-137, for Class C disposal, no more than 30 Ci can be encapsulated, at the time of disposal.

Review of Existing Encapsulation Guidance

Stakeholders requested a review of several aspects of the encapsulation guidance, including: the 0.2 m^3 volume limit, the limit of only one item per package, and in particular the 30 Ci limit for Cs-137 (given that the Class C limit for Cs-137 is 4,600 Ci/m^3 and 30 Ci in 0.2 m^3 is only 150 Ci/m^3). In response to these requests, staff reviewed the basis for each element of the 1995 encapsulation guidance.

A fundamental element of the 1995 guidance is the ability to average the activity in the encapsulated item over the larger volume of the encapsulating media, so long as the Branch Technical Position on Concentration Averaging and Encapsulation activity limits are not exceeded. Those activity limits are established to ensure that potential doses to an inadvertent intruder are acceptable, should there be a loss of the encapsulating media. Inadvertent human intruder exposure scenarios presented in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation were used to set the gamma-emitting activity (curie) limits for encapsulated items. The exposure scenarios used to set the 30 Ci Class C activity limit for Cs-137 includes the assumption that the intruder is 1 meter from the item for 2,360 hours.

Development of New Guidance

The inadvertent intruder scenario that was used to set the gamma-emitting activity limits in 1995 (inadvertent exposure at 1 m for 2,360 hours) was determined to be unreasonable, and a more reasonable scenario was developed for setting the gamma-emitting limits. A number of factors were considered in developing the new exposure scenario-basis for setting the gamma-emitting activity limits for encapsulated items. The staff understands that the 1995 Branch Technical Position on Concentration Averaging and Encapsulation was issued, in part, in response accidents involving small, highly radioactive sealed sources. The nature of these sealed source accidents led the NRC to consider individual gamma-emitting items that might survive in a LLW disposal facility, and the possibility that their radioactive nature would not be recognized by an inadvertent intruder.

Staff reviewed the circumstances surrounding a number of these accidents [4][5][6]. These highly-publicized accidents share a number of common elements including: a loss of regulatory control; the victims were engaged in normal activities and the radiological hazards associated with these small pieces of metal were not recognizable. Many of these accidents resulted in fatalities (adults and children). These accidents are unlikely, but when they do occur, the consequences can be quite severe. The worst of these accidents resulted in large social disruptions, a very expensive cleanup, and radiation doses leading to several deaths [4].

Considering a number factors, including the circumstances surrounding the sealed source accidents, staff developed a Gamma-Emitting Small Item Carry-Away Scenario which was used to propose new activity limits on the primary gamma-emitting nuclides that can be encapsulated. The details of this scenario are presented in the Appendix of the revised draft of the Branch Technical Position on Concentration Averaging and Encapsulation. Briefly, 500 years after closure of a LLW landfill, the LLW containers and encapsulating materials have decayed, leaving an intact stainless steel Cs-137 sealed radioactive source. A public works project, such as the construction of a regional pipeline, cuts through the former landfill exposing the sealed source. An individual finds the source in the excavated soil. Because there is no indication of a hazard, the individual takes this interesting piece of metal home, where it is placed on a shelf.

Using MicroShield®, the NRC determined that a 130 Ci Cs-137 source (at the time of disposal) would result in a 500 mrem dose to the intruder at 500 years. Thus the activity of Cs-137 should be limited to 130 Ci at the time of encapsulation/disposal as Class C LLW to ensure that intruder doses do not exceed 500 mrem. This same scenario was used to establish new Class A and B limits for encapsulation of Cs-137, and for establishing limits for Nb-94 and Co-60. Because of its short half-life, there is no Class B or C limit for encapsulated Co-60. These draft limits are shown in Table 1.

Inadvertent intrusion is only expected if required markers, barriers, active and passive institutional controls and societal memory are lost. This makes inadvertent intrusion unlikely, but possible, especially as time passes after closure of the disposal facility. However, there is no scientific basis for quantitatively predicting the nature or probability of a future human activity [7]. Therefore, this inadvertent intruder assessment does not explicitly consider the probability or likelihood of inadvertent intrusion occurring. Rather, the assessment uses a reasonably bounding scenario (or scenarios) to set limits, to protect the intruder should intrusion occur.

In reviewing the other key limits from the encapsulation guidance, the staff determined that the 1995 limits should be retained, for the maximum encapsulating volume or mass, and for the maximum activity of non-gamma emitting nuclides. The 1995 limit of one item per encapsulation package was relaxed to allow the encapsulation of multiple items, so long as other encapsulation criteria are met. Finally and importantly, the proposed Alternative Approaches provides detailed guidance for site specific deviations from the encapsulation guidance.

Stakeholders have commented on the proposed revisions to the encapsulation position in the Branch Technical Position on Concentration Averaging and Encapsulation. Some were strongly in favor of the proposed changes and the ability of sealed source holders to dispose of significantly more sources if the Branch Technical Position on Concentration Averaging and Encapsulation limits are adopted by the States. Others questioned the scenario used to establish the new source limits. Another comment received from stakeholders was that the parameters associated with sealed source accidents are not applicable to disposal sites where access to sources is so restricted. The staff is addressing these comments as it develops a revision due to be published in the Spring of 2011.

Table I. Classification limits for Gamma-Emitting Sealed Sources

Nuclide	Waste Classified as Class A	Waste Classified as Class B	Waste Classified as Class C
Co-60	**140 Ci**	**No Limit.**	**No limit.**
Nb-94	**1 mCi**	**1 mCi**	**1 mCi**
Cs-137/Ba- 137m	**0.0072 Ci**	**0.72 Ci**	**130 Ci**

Classifying a Mixture of Activated Metals or Contaminated Materials or Cartridge Filters

Existing Guidance

For classifying a container of multiple items of activated metals, or contaminated materials, or cartridge filters, the 1995 Branch Technical Position on Concentration Averaging and Encapsulation provides separate, but very similar guidance, for each waste type. Simplified, the 1995 guidance allows licensees to classify a mixture based on: (a) the classification of the item in the mixture with the highest classification, or (b) the mathematical average of the items (i.e.,

total activity divided by volume of the items); so long as individual hot spots (higher activity items) do not compromise the safety of the inadvertent intruder.

There are two tests to identify (for removal) higher activity gamma-emitting items, and two tests to identify (for removal) higher activity non-gamma emitting items. For clarity, these are named tests, one, two, three and four. The first test for gamma-emitting items is to ensure that sealed-source like items are removed; these are items (a) with a volume less than 0.01 ft^3, and (b) with activity that exceeds the values shown in Table A in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation. The Table A values are identical to the encapsulation limits for the primary gamma-emitting nuclides; and if the activity level of a small item is too high to be encapsulated, it is also too high to be averaged in a mixture of items. The second test is applied if the primary gamma-emitters control the classification of the mixture. The second test in the 1995 version states that if the concentration of a classification-controlling primary gamma-emitting nuclide in any item of the mixture is greater than 1.5 times the average activity of that nuclide in the mixture, the item must be removed (this is known as the Factor of 1.5 Rule)[8].

The third test in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation is for the non-gamma-emitting items and this test ensures that the total activity in any item does not exceed the activity that could be average across a volume of 0.2 m^3 (this is the Table B test). The Table B values are identical to the encapsulation limits for the non-gamma-emitting nuclides; and if the activity level of an item is too high to be encapsulated, it is also too high to be averaged in a mixture of items. The fourth test is for the non-gamma-emitting items and this test states that if the concentration of a non-gamma-emitting nuclide in any item of the mixture is greater than 10 times the average activity of that nuclide in the mixture, the item must be removed.

Review of Existing Guidance

Stakeholders requested a review of several aspects of the guidance for classifying a mixture of activated metals or contaminated materials or cartridge filters, including: the factor of 1.5 Rule for the gamma emitters and the classification of cartridge filters using the same criteria that is used for pieces of activated metal. In response to these requests, staff reviewed the basis for each element of the 1995 guidance.

Staff determined that, in general, cartridge filters may be constructed of decay resistant materials such as stainless steel, and therefore cartridge filters should be managed like pieces of activated metal or contaminated materials. However, the proposed Alternative Approaches provides detailed guidance for deviations from this position.

The Factor of 1.5 Rule for gamma-emitting pieces was also reviewed by the staff. This rule is based on an intruder exposure scenario briefly described in the 1995 Branch Technical Position on Concentration Averaging and Encapsulation. In this scenario, pieces of activated metal are excavated from a LLW landfill and the hazard is not recognized and the pieces are arranged in the shape of a disk with a diameter of 3.34 m, with the intruder being exposed at the center of the disk.

Development of New Guidance

The Table A test for removing sealed-source like items from a mixture was retained and Table A was updated to reflect the proposed activity limits for encapsulating primary gamma-emitting nuclides discussed earlier. If the activity level of a small item is too high to be encapsulated, it is also too high to be averaged in a mixture of items.

The inadvertent intruder scenario that was used to set the Factor of 1.5 limit for gamma-emitting activity in 1995 (inadvertent excavation and pieces arranged in the shape of a disk with a diameter of 3.34 m) was determined to be unreasonable, and a more reasonable scenario was developed for setting the gamma-emitting limits. A number of factors were considered in developing a new inadvertent intruder exposure scenario that was used to establish a new Factor of 1.5 Rule. The Gamma-Emitting Larger Items Carry-Away Scenario is similar to the Gamma-Emitting Small Item Carry-Away Scenario discussed earlier. In the Gamma-Emitting Larger Items Carry-Away Scenario, pieces of Nb-94 activated metal are unearthed by a civil works project, and not recognizing the hazard, the workers use equipment to bring the metal back to their shop for storage and resale as scrap metal. Based on details presented in the draft revised Branch Technical Position on Concentration Averaging and Encapsulation, concentrations of the primary gamma-emitting nuclides should not exceed two times the appropriate classification limit (e.g., the Class C limit), so as to prevent the intruder from receiving doses greater than 500 mrem.The Factor of 2 Rule is linked to the appropriate classification limit, and not to the average activity of that nuclide in the mixture Figure 2 graphically illustrates the differences between the existing Factor of 1.5 Rule and the proposed Factor of 2 Rule.

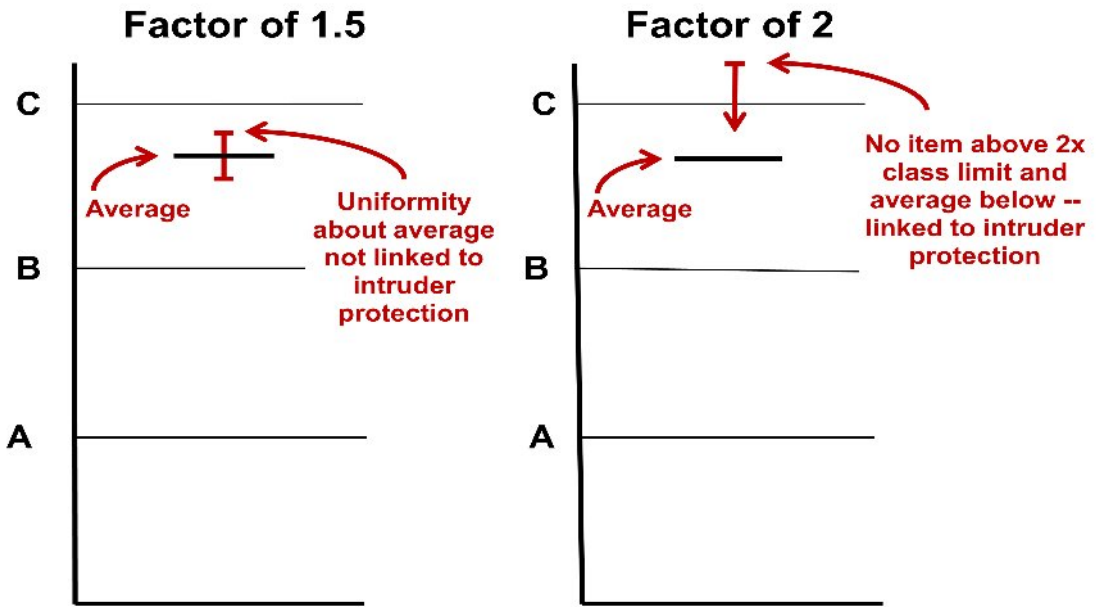

Fig. 2 Difference Between Factor of 1.5 Rule and Proposed Factor of 2 Rule

The third test and forth tests from the 1995 Branch Technical Position on Concentration Averaging and Encapsulation (for the non-gamma-emitting items) were retained. However, the Factor of 10 Rule is proposed to be linked to the appropriate classification limit (e.g., the Class

C limit) for each non-gamma-emitting nuclide, rather than being linked to the average activity for that nuclide in the mixture.

Cartridge Filters

The current version of the Branch Technical Position on Concentration Averaging and Encapsulation does not denote cartridge filters as homogeneous; therefore, they are considered individual items that are subject to certain averaging constraints. Being individual items, the 1995 Branch Technical Position on Concentration Averaging and Encapsulation recommends that cartridge filters be classified by dividing activity by weight or volume of the filter (envelope volume is acceptable). Mixing of cartridge filters is permissible and concentration averaging is allowed using certain constraints that are applicable to non-homogeneous waste. It is also permissible to conservatively base the classification on the highest classification associated with any single filter. As previously discussed, the distinguishing characteristic of homogeneous wastes is that their radionuclide concentrations are likely to approach uniformity in the context of reasonably foreseeable intruder scenarios. The staff believes this will not be the case with at least some cartridge filter designs. Some filters (e.g., pressurized water reactor (PWR) primary system filters) are much more durable in the disposal environment than others. These would most likely not degrade as quickly leaving the enclosed filter media, which should degrade like other homogeneous waste, unavailable for mixing with surrounding soil per the intruder scenarios.

Based on observations of filters, the staff believes that the enclosure could continue to retain the filter media and radioactivity, thereby preventing the radionuclide concentrations from approaching uniformity, at least for some intruder scenarios. In addition, cartridge filters from reactor coolant systems, spent fuel clean-up, and other sources, are typically classified as Class B or C whereas the majority of DAW is classified as Class A. In intruder scenarios, the consequence of an encounter with a hot spot is greater with filters than with DAW. Staff has therefore determined that cartridge filters in general should continue to be classified using the existing guidelines. At the same time, the staff recognizes that some cartridge filters could likely be considered as homogeneous, i.e., that their radionuclide concentrations would become nearly uniform in the context of reasonably foreseeable intruder scenarios. In Section 3.9 of the revised draft Branch Technical Position on Concentration Averaging and Encapsulation, the staff has added cartridge filters as one of the items that can be considered for alternative provisions under the Branch Technical Position on Concentration Averaging and Encapsulation.

Alternative Approaches

The proposed revision to the Branch Technical Position on Concentration Averaging and Encapsulation significantly revises the 1995 version's guidance for averaging approaches different from those specified in the body of the document The goal with this revised approach is to make the Branch Technical Position on Concentration Averaging and Encapsulation more performance-based, that is, to permit licensees to propose alternatives to the positions in the Branch Technical Position on Concentration Averaging and Encapsulation, as long as the performance goal—protection of an inadvertent intruder—is maintained.

The 1995 Branch Technical Position on Concentration Averaging and Encapsulation established a high bar for deviating from the recommendations in the position. In practice, the NRC staff is aware of only one alternative approach that was approved by regulators. The Branch Technical Position on Concentration Averaging and Encapsulation states that alternative

approaches for averaging should be approved under NRC's regulation in 10 CFR 61.58. This provision states that "The Commission, upon request, may authorize provisions for the classification and characteristics of waste on a specific basis if, after evaluation of the specific characteristics of the waste, disposal site, and method of disposal, it finds reasonable assurance of compliance with the performance objectives in Subpart C of 10 CFR Part 61.

This provision applies to approaches different from those specified in the disposal *regulations*, not in staff *guidance*. In practice, the staff believes that this provision of the 1995 Branch Technical Position on Concentration Averaging and Encapsulation has deterred licensees from proposing different averaging approaches. In addition, not all regulatory authorities for States that license disposal site have this provision in their regulations, and so the regulatory mechanism for obtaining approval of alternatives is not available to all licensees. The revised Branch Technical Position on Concentration Averaging and Encapsulation, instead of referring to 10 CFR 61.58 for obtaining approval of alternative approaches to averaging, uses language consistent with other NRC guidance documents. It states that the guidance is provided to describe, and make available to NRC licensees, Agreement States, and the public, methods that the NRC staff believes may be acceptable for implementing specific parts of the Commission's regulations, and to provide advice to regulated entities. It notes that the positions in the Branch Technical Position on Concentration Averaging and Encapsulation are not intended as substitutes for regulations, and compliance with them is not required.

Acknowledging that alternatives to the Branch Technical Position on Concentration Averaging and Encapsulation positions may be appropriate is consistent with the Commission's position of using performance-based regulation of licensees. One of the components of the Commission's definition of "performance-based" regulation is that ". . . licensees have flexibility to determine how to meet the established performance criteria in ways that will encourage and reward improved outcomes."[3] For the Branch Technical Position on Concentration Averaging and Encapsulation, the primary performance criterion is protection of the inadvertent intruder, one of the four performance objectives in Subpart C of 10 CFR Part 61. The waste classification system and concentration averaging are means to that end, but other approaches for classification or averaging may be appropriate and justified. For example, the 10 CFR 61 waste classification system was developed based on analysis a generic disposal facility. Similarly, the averaging provisions in the Branch Technical Position on Concentration Averaging and Encapsulation are based on generic analyses. Safe alternative approaches to averaging could be proposed based on a specific site and disposal facility design. For example, if a site-specific analysis can show that encapsulated sources buried more than 10 meters below the surface are not subject to human intrusion that would be a basis for not having to meet the averaging constraints in the Branch Technical Position on Concentration Averaging and Encapsulation for sealed sources.

The revised Branch Technical Position on Concentration Averaging and Encapsulation, in addition to providing a simpler process for approving alternatives, also provides examples of alternatives that may be acceptable. These include:

- Demonstrating that contaminated materials or cartridge filters may not have to be subject to the averaging constraints in the Branch Technical Position on Concentration

[3] NUREG-1614, Volume 4, NRC "Strategic Plan Fiscal Years 2008-1013," 2008.

Averaging and Encapsulation, if it can be shown that they become soil-like by the time of human intrusion.

- Allowing for the disposal of larger activity sources than the Branch Technical Position on Concentration Averaging and Encapsulation stipulates, if it can be shown that the container in which a sealed source is disposed of would provide protection, or if the disposal depth were greater.

- Allowing for consideration of likelihood of intrusion.

- Allowing for averaging over larger volumes, such as large reactor components.

The revised Branch Technical Position on Concentration Averaging and Encapsulation provides flexibility to generators and processors, while at the same time ensuring that intruder protection will be maintained. Licensees can routinely use the concentration averaging provisions in the body of the Branch Technical Position on Concentration Averaging and Encapsulation. Licensees may also, however, obtain approval for different approaches when warranted. The revised Branch Technical Position on Concentration Averaging and Encapsulation explicitly acknowledges the appropriateness of alternative approaches.

Stakeholders also commented on this portion of the revised Branch Technical Position on Concentration Averaging and Encapsulation. While all commenters to date have favored the revised approach for alternatives, some also believe that additional details should be provided in the examples for considerations that licensees and regulators will need to address in developing and reviewing an alternative approach.

FUTURE

The NRC staff is in the process of revising the Branch Technical Position on Concentration Averaging and Encapsulation. The NRC views nuclear regulation as the public's business and, as such, believes it should be transacted as openly and candidly as possible to maintain and enhance the public's confidence. The staff encourages stakeholders to participate in the Branch Technical Position on Concentration Averaging and Encapsulation revision process. The staff plans to publish the next Branch Technical Position on Concentration Averaging and Encapsulation revision at the end of April 2012. The staff will be asking for stakeholder comments on the revised Branch Technical Position on Concentration Averaging and Encapsulation. Each comment provided to the NRC will be addressed and added to Appendix C of the Branch Technical Position on Concentration Averaging and Encapsulation itself.

SUMMARY

U.S. Nuclear Regulatory Commission (NRC) staff has developed a revised Branch Technical Position on Concentration Averaging and Encapsulation, improving the organization and clarity of the document, and better documenting bases for the positions. The revision alsoas revised several aspects of the guidance to be more risk informed and performance based. The Branch Technical Position on Concentration Averaging and Encapsulation designates homogeneous waste types, provides guidance for demonstrating wastes are homogenous, and provides guidance regarding the uncertainty in waste classification calculations for homogeneous wastes . The Branch Technical Position on Concentration Averaging and Encapsulation has revised

the scenarios, using a more realistic approach, which has lead to an increase in the suggested limits for disposal of sealed sources. Specifically the activity limits for gamma-emitting sealed sources, Cs-137 and Co-60, have been increased. The changes to the sealed source position, if adopted by Agreement States, has the potential to provide a disposal pathway for numerous sources that are currently being stored and without a disposal pathway. Permanent disposal options will help reduce the safety and security risks. The revised guidance also includes a new alternative approach section that provides flexibility to generators and processors, while also ensuring that intruder protection will be maintained. Alternative approaches provide flexibility by (1) allowing for consideration of the likelihood of intrusion, (2) allowing for the possibility of averaging over larger volumes (i.e. larger component disposal), and (3) allowing for disposal of large activity sealed sources. The revision has improved the organization and clarity of the Branch Technical Position on Concentration Averaging and Encapsulation and has better documented the bases for positions. The NRC staff's believes the Branch Technical Position on Concentration Averaging and Encapsulation meets the goal of providing a more risk-informed and performance-based document while also maintaining protection for intruder as described in 10 CFR Part 61.

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