EPI HLW-102-1117
HLW & FD EIS PROJECT - AR/PF
Control # 6793

January 17, 1995

ATTENTION: Commission Licensees

SUBJECT: ISSUANCE OF FINAL BRANCH TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION, REVISION IN PART TO WASTE CLASSIFICATION TECHNICAL POSITION

The regulation, "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 [on the values tabulated in the concentration tables] are expressed as nanocuries per gram" [text added for clarity]. The enclosed Technical Position defines a subset of concentration averaging and encapsulation practices that the NRC staff would find acceptable in determining the concentrations of the 10 CFR 61.55 tabulated radionuclides in low-level waste.

On June 26, 1992, Commission licensees were sent copies of a proposed "Concentration Averaging and Encapsulation Technical Position, Revision in Part," on which comments were solicited. A notice of availability of the proposed Technical Position was also published in the Federal Register on June 30, 1992 (57 FR 29105). In response, nineteen comment letters were received suggesting the need for further expansions of, and several modifications to, the Technical Position. Consideration of these comments resulted in modifications and an expansion of the Technical Position. A notice of availability of the modified Technical Position was again published in the Federal Register on September 22, 1993 (58 FR 4933) and, because of the significant interest expressed by the original commenters, was again issued for comment in proposed form. Thirteen comment letters were received, suggesting further clarifications and resurfacing position justification issues raised on the initial proposal. Many of the suggested clarifications

INFORMATION ONLY

have been included in the final technical position (Enclosure 1), and further discussion and technical basis information have been attached to respond to the "position justification" and other comments. Enclosure 2 provides additional explanation of the technical bases for the concentration averaging and encapsulation positions involving the classification of certain "discrete" waste types.

The final technical position has been supported by the Conference of Radiation Control Program Directors' E-5 Committee on Low-Level Radioactive Waste Management. Through continued coordination with the E-5 Committee, the goal has been to develop a subset of concentration averaging and encapsulation positions that would be generally accepted by the States that will be licensing many of the future low-level radioactive waste disposal sites. Because the guidance can not address all unique waste types or waste packaging methods, an "Alternative provisions" paragraph is included that defines the bases and procedures through which other classification averaging or encapsulation positions may be judged acceptable.

Questions on the final position may be referred to William Lahs, U.S. Nuclear Regulatory Commission, Mail Stop 7F-27, Two White Flint North, Washington, DC 20555, telepnone (301) 415-6756. The information collections contained in the Technical Position have been approved under the Office of Management and Budget number 3150-0014.

MR Knapp

Malcolm R. Knapp, Director
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures: As stated

BRANCH TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION

CONTENTS

Page:

A. INTRODUCTION.....1

B. DISCUSSION.....2

C. REGULATORY POSITION.....2

C.3 Volumes and Masses for Determination of Concentration..... 2

3.1 Mixing of homogeneous waste types or streams.....4

3.2 Solidified and absorbed liquids.....5

3.3 Mixing of activated materials or metals, or components incorporating radioactivity in their design.....5

3.3.1 Averaging involving primary gamma-emitters.....6

3.3.2 Averaging of sections or pieces of larger components containing primary gamma-emitters.....6

3.3.3 Averaging involving radionuclides other than primary gamma-emmitters.....6

3.3.4 Averaging involving sections or pieces of larger components containing other than primary gamma-emitters.....7

3.3.5 Mixtures containing multiple radionuclides.....7

3.3.6 Illustrative examples.....9

Example 1.....9

Example 2.....9

Example 3.....12

3.4 Contaminated materials.....13

3.4.1 Averaging involving primary gamma-emmitters.....14

3.4.2 Averaging of sections or pieces of larger components containing the primary gamma-emitters.....14

3.4.3 Averaging involving radionuclides other than primary gamma-emmitters.....14

CONTENTS, Cont:

3.4.4 Averaging involving sections of pieces of larger contaminated items or components containing other than primary gamma-emmitters....15

3.4.5 Mixtures containing multiple radionuclides....15

3.5 Mixing of cartridge filters....16

3.5.1 Averaging involving primary gamma-emmitters....16

3.5.2 Averaging involving radionuclides other than primary gamma-emmitters....17

3.5.3 Mixtures containing multiple radionuclides....17

3.5.4 Illustrative example....18

3.6 Waste in high-integrity containers....18

3.7 Encapsulation of solid material....19

3.8 Mixing of dissimilar waste streams (different waste types)....19

3.9 Alternative provisions....20

APPENDIX C POSITION ON ENCAPSULATION OF SEALED SOURCES AND OTHER SOLID LOW-LEVEL RADIOACTIVE WASTES....22

TABLES

A. Activity Levels in Individual Sections or Pieces of Larger Components Potentially Requiring Their Piecemeal Consideration in Classification Determinations - Primary gamma-emitters....7

B. Activity Levels in Individual Sections or Pieces of Larger Components Requiring Their Piecemeal Consideration in Classification Determinations - Other than primary gamma-emitters....8

C. Volumes and Masses for Determination of Concentrations....21

FIGURE

1. Logic Diagram for Classifying Waste Comprised of Activated Metal or Components Containing Radioactivity in their Design....10-11

TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION

A. INTRODUCTION

The U.S. Nuclear Regulatory Commission requires that a proposed low-level radioactive waste disposal site undergo a performance assessment that demonstrates compliance with the performance objectives stated in 10 CFR 61.41. In addition, to provide protection, for individuals, from inadvertent intrusion (i.e., 10 CFR 61.42), radioactive waste proposed for near-surface disposal must be classified to ensure its suitability for such disposal. The regulation, "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, in 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 [on the values tabulated in the concentration tables] are expressed as nanocuries per gram" [text added for clarity].

A technical position on radioactive waste classification was initially developed in May 1983. This initial position included a section, "Concentration Volumes and Masses," that provided guidance to waste generators on the interpretation of 10 CFR 61.55(a)(8) as it applies to a variety of different types and forms of low-level waste. This position expands on, further defines, and replaces that guidance which was provided in Section C.3 of this original 1983 Technical Position. The other sections of this 1983 Technical Position remain in effect, with the exception of the corrections noted in the footnote below.[1] The recommendations and guidance provided in this Section C.3 revision represent acceptable methods by which specific waste streams or mixtures of these waste streams may be classified against the tabulated concentration values defined in Tables 1 and 2 of 10 CFR 61.55. The guidance is not intended to address all unique waste types or waste packaging methods. Other provisions for the classification of these specific wastes or waste mixtures may be deemed acceptable, as discussed under the "Alternative

---

[1] The following corrections should be made to the May 1983, Technical Position: (1) p. 1, first para., fourth line -- delete the words, "or processor"; and (2) p. 6, fourth line and p. 12, second para., fifth line -- replace "biannual" with "biennial."

provisions" paragraph of this revision. Furthermore, if necessary, it is intended that the provisions in this paragraph be used to preclude reclassification of waste material that was packaged and classified before the issuance of this expanded guidance, if the waste were classified in accordance with accepted practices at the time of packaging.

B. DISCUSSION

Each shipment of radioactive waste to a licensed operator of a land disposal facility must be accompanied by a shipment manifest. In the manifest, the shipper/consignor-licensee must classify and clearly identify waste as Classes A, B, or C, in accordance with 10 CFR 61.55. Determination of the classification of waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides in the waste, with respect to the values given in Table 1 of 10 CFR 61.55. Second, consideration must be given to the concentration of short-lived radionuclides in the waste, with respect to the values given in Table 2 of 10 CFR 61.55.

Waste is determined to be generally unacceptable for near-surface disposal if it contains any of the radionuclides listed in Tables 1 and 2, of 10 CFR 61.55, in concentrations exceeding the applicable limits established for the individual radionuclides.

C. REGULATORY POSITION

* * * * *

3. Volumes and Masses for Determination of Concentration[2]

Paragraph 61.55(a)(8) states that, for the purposes of waste classification, the concentration of a radionuclide may be averaged over the volume of the waste, or the weight of the waste, for those concentration units, in

---

[2] It should be noted that waste acceptance requirements for disposal facilities licensed by Agreement States (e.g., requirements for encapsulated wastes or activated metals) may differ from this guidance. Waste generators should consult with disposal site operators or appropriate regulatory authorities before classifying these wastes.

10 CFR 61.55, Table 1 that are expressed as nanocuries per gram. This requirement needs interpretation because of the different types and forms of low-level waste. Principal considerations include: (1) whether the distribution of radionuclides within the waste can be considered to be reasonably homogeneous (i.e., volume distributed); (2) whether the "as-generated" waste has been processed and, if so, what is the mass/volume of the processed waste; (3) whether the waste includes mixtures of various waste types (i.e., a waste stream with a particular set of physical characteristics); (4) whether the waste includes mixtures of the same waste type, but at differing radioactivity concentration levels; and (5) whether the volume of the waste container, if used to represent the volume of the waste, is significantly larger than the volume of the waste itself, and the differential volume consists largely of void space.

With regard to the above considerations, many waste types may be considered to be homogeneous, for purposes of waste classification. A homogeneous waste type is one in which the radionuclide concentrations are likely to approach uniformity in the context of the intruder scenarios used to establish the values included in Tables 1 and 2 of 10 CFR 61.55 (i.e., intruder interactions with the waste are assumed to take place 100 years or more after disposal site closure). Such waste types would include, for example, spent ion-exchange resins, filter media, solidified liquid, evaporator bottom concentrates, or contaminated soil. Contaminated trash waste, which is composed of a variety of miscellaneous materials, may be considered homogeneous for purposes of waste classification, when placed in containers. To the extent that contaminated trash and contaminated soil are packaged in a disposal container to achieve ≥90 percent fill, the volumetric-averaged concentration of radionuclides in these waste types can be based on the fill-volume of the container. Alternatively, the volume of the waste can be calculated from the weight of the container contents, divided by the density of the contents. A representative density, based on a representative distribution of materials as they occur in waste, may be used.

For certain waste types (i.e., spent ion-exchange resins and filter media), care needs to be taken to differentiate between the volume of the waste form and the volume of the waste container. Although free volume should be reduced to the extent practicable, these wastes may be contained within a disposable

demineralizer, liner, or high integrity container (HIC) with some waste-free volume. In such cases, the volume or weight used for waste classification should be the displaced or bulk volume (interstitial space may be included) or dewatered weight of the resins or filter media, rather than the gross internal volume of the container or the weight of the resins before dewatering.

The following paragraphs provide guidance on a subset of acceptable classification or encapsulation practices. Other provisions for classification or encapsulation of specific waste may also be deemed acceptable, as discussed in the "Alternative provisions" paragraph at the end of this section.

3.1 Mixing of homogeneous waste types or streams

Mixing of similar homogeneous waste types (e.g., spent ion-exchange resins or contaminated soils) is permissible as described below. Note, however, that a designed collection of homogeneous waste types from a number of sources within a licensee's facility, for purposes of operational efficiency or occupational dose reduction, is not considered "mixing," for purposes of this position. Under the guidance in this position, the classification of a mixture, using the sum of fractions rule specified in 10 CFR 61.55, should be based on either: (a) the highest nuclide concentrations in any of the individual waste types contributing to the mixture; or (b) the volumetric- or weight-averaged nuclide concentrations of the mixture, provided that the concentrations of the individual waste type contributors to the mixture are within a factor of 10 of the average concentration of the resulting mixture.

Mixing of dissimilar homogeneous waste streams may also be permissible, but should receive appropriate regulatory approval under the "Alternative provisions" paragraph of this position.

In any of the above cases, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the waste must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of a mixture is based on the volumetric- or weight-averaged nuclide concentration of the mixture (e.g., as allowed under (b) above), the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record

documenting the licensee's waste classification analysis. It is generally expected that this record or analysis, in and of itself, should be sufficient to show that the mixing was undertaken under the provisions of this position.

3.2 Solidified and absorbed liquids

Classification of evaporator concentrates, filter backwashes, liquids, or ion-exchange resins solidified in a manner to achieve homogeneity or meet the stability criteria of 10 CFR 61.56 should be based on solidified nuclide activity divided by the volume or weight of the solidified mass. Because absorbed liquid wastes do not appreciably bind nuclides, classification of absorbed liquids should be based on the absorbed activity divided by the volume or mass of the liquids before absorption.

3.3 Mixing of activated materials or metals, or components incorporating radioactivity in their design

For neutron-activated materials or metals, or components incorporating radioactivity in their design, the waste classification volume or weight should be taken to be the total weight or displaced volume of the material, metal, or component (i.e., major void volumes subtracted from the envelope volume).

Mixtures of activated materials, metals, or components in a disposal container or liner are permissible. In determining the classification of such a mixture, it is always permissible to conservatively base the mixture classification on the highest classification associated with any piece, section, or component within a disposal container or liner. It is also permissible, under the following constraints, to average the concentrations of the radionuclides listed in 10 CFR 61.55, Table 1 and Table 2, over contents of the disposal container or liner. Because of the potential non-homogeneity of the waste, the classification of the combined waste may be affected by whether the waste contains the primary gamma-emitting nuclides (Co-60, Nb-94, or Cs-137/Ba-137m). For the purpose of applying the guidance under these paragraphs, a component may be considered to be that portion of an original component that is placed in the disposal container being classified. Although components may be comprised of multiple sections or pieces to effectuate packaging, the component (not the pieces or sections thereof) is the discrete item to which this guidance applies.

In determining the classification of the container/liner, one or more of the following paragraphs may apply, as indicated in the logic diagram (Figure 1) on pages 10 and 11.

3.3.1 Averaging involving primary gamma-emitters

For the purpose of classifying a mixture of items or components containing the primary gamma-emitters (i.e., Co-60, Nb-94, or Cs-137/Ba-137m) for which these nuclides dictate the classification of the waste, their individual nuclide concentrations may be based on the volumetric-averaged concentration of the combined materials, provided that the concentrations within the individual items or components of the mixture in the disposal container or liner are within a factor of 1.5 of the respective averaged concentration value for each nuclide. Averaging is always allowed for a primary gamma-emitting nuclide if its activity within an item or component is less than 37 MBq (1 mCi).

3.3.2 Averaging of sections or pieces of larger components containing the primary gamma-emitters

Individual sections of pieces of larger components that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items if:

(a) the volume of the piece or section is less than one-hundredth of a cubic foot (0.01 ft^3) or 0.00028 cubic meters (0.00028 m^3) -- such a piece will typically weigh less than 10 pounds (10 lbs) or 4.54 kilograms (4.54 kg), and

(b) the specific nuclide activity in the piece or section is greater than the appropriate value shown in Table A.

3.3.3 Averaging involving radionuclides other than primary gamma-emitters

For the purpose of classifying a mixture, the concentrations of all 10 CFR 61.55 tabulated radionuclides in the disposal container or liner, other than Co-60, Nb-94, or Cs-137/Ba-137m, may be based on the volumetric- or weight-averaged concentrations of the combined materials. In this case, all

the concentrations of the "classification-controlling" individual nuclides[3] within all the individual items should be within a factor of 10 of their respective averages over all items in the mixture.

TABLE A

Activity Levels in Individual Sections or Pieces of Larger Components Potentially Requiring Their Piecemeal Consideration in Classification Determinations

Nuclide	For Waste Classified as Class A or B	For Waste Classified as Class C
Co-60	>26 TBq (700 Ci)	N.A.
Nb-94	>37 MBq (1 mCi)	>37 MBq (1 mCi)
Cs-137/Ba-137m	>111 MBq (3 mCi)	>1.1 TBq (30 Ci)

3.3.4 Averaging involving sections or pieces of larger components containing other than primary gamma-emitters

Individual sections or pieces of larger components, in a disposal container, that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items, if the nuclide activity in the piece or section exceeds the appropriate value indicated in Table B.

3.3.5 Mixtures containing multiple radionuclides

For activated materials, metals, or components containing combinations of tabulated nuclides, the sum-of-the-fractions rule described in 10 CFR 61.55(a)(7) would apply. This rule involves the summing of the fractions of the appropriate 10 CFR 61.55 Table 1 or 2 concentration values, as described in 10 CFR 61.55(a)(7). The sum of the fractions rule could involve summing the fraction of the appropriate 10 CFR 61.55 Table 1 or

[3] A "classification-controlling" nuclide is one that is contained in waste in concentrations greater than 0.01 times the concentration of that nuclide listed in Table 1 or 0.01 times the applicable class-dependent concentration of that nuclide in Table 2, Column 2 or 3. Note that a nuclide may be significant for reporting purposes under Section 4 in the May 1983 Technical Position and yet not be a "classification-controlling" nuclide.

Table 2 concentration values associated with the primary gamma-emitting nuclides and the fractions of tabulated concentrations associated with the other nuclides. The respective fractions contributing to the sum can be calculated by using the "highest concentration" existing in any item within the mixture or, if applicable, the concentration determined by using the "averaging" methods described previously.

TABLE B

Activity Levels in Individual Sections or Pieces of Larger Components Requiring Their Piecemeal Consideration in Classification Determinations

Nuclide*	For Waste Classified as Class A or B	For Waste Classified as Class C
H-3	>0.3 TBq (8 Ci)	N.A.
C-14	>0.04 TBq (1 Ci)	>0.4 TBq (10 Ci)
Ni-59	>0.15 TBq (4 Ci)	>1.5 TBq (40 Ci)
Ni-63	>0.26 TBq (7 Ci)	>55 TBq (1500 Ci)
Alpha emitting TRU with half-life greater than 5 years (excl. Pu-241 and Cm-242)	>111 MBq (3 mCi)	>1110 MBq (30 mCi)

* Other nuclides listed in the tables in 10 CFR 61.55 are not expected to be of importance in determining waste classification.

Independent of the method chosen, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the mixture of items must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of the mixture of items is based on the volumetric- or weighted-averaged nuclide concentrations of any of the items in the disposal container/liner, as allowed above, the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analysis. It is generally expected that this record or analysis, in and of itself, should be sufficient to show that the averaging of concentrations over some or all the contents in the disposal container/ liner was undertaken under the provisions of this position.

3.3.6 Illustrative examples

Example 1: Three equally sized control rod blades are contained in a liner. The blades (0.6 ft^3 or 0.017 m^3) contain, respectively, concentrations of Nb-94 that are 0.9, 0.7, and 0.5 of the 10 CFR 61.55, Table 1, value for Nb-94, of 0.2 curies per cubic meter. The blades also contain Ni-59 in concentrations of 44, 22, and 11 curies per cubic meter. These concentrations are 0.2, 0.1, and 0.05 of the 10 CFR 61.55, Table 1, value for Ni-59, of 220 curies per cubic meter. The Nb-94 concentrations in the three blades are all within a factor of 1.5 of the average concentration within three blades (i.e., 0.14 curies per cubic meter). Likewise, the Ni-59 concentrations in the three blades are all within a factor of 10 of the average concentration within the three blades (i.e., 26 curies per cubic meter). The sum of the fractions for the blades in the liner would be calculated by summing 0.7 (the averaged Nb-94 fraction for the blades) and 0.12 (the fraction for the Ni-59 activity averaged over all three blades). The sum, 0.82, would qualify the liner as containing Class C waste.

Example 2: The cruciform section of a boiling-water reactor control rod blade (0.6 ft^3 (0.169 m^3) and 200 lbs. (90.8 kg)) contains a Nb-94 concentration of 0.16 curies per cubic meter, a Ni-59 concentration of 22 curies per cubic meter, and a Ni-63 concentration of 5000 curies per cubic meter. The blade, as a whole, would be classified as Class C waste (i.e., Nb-94 fraction (0.8) + Ni-59 fraction (0.1) = 0.9, using the sum of the 10 CFR 61.55, Table 1, fractions; the Ni-63 concentration is less than the respective Table 2, Column 3 value). The blade, however, is sectioned into four equal pieces to facilitate shipment. The "hottest" piece contains 80 percent of the blade's activity. This piece would contain a concentration of Nb-94 above the 10 CFR 61.55, Table 1, value. However, if pieces of the blade contained in the same disposal container are less than Class C limits on the average, the container could be classified as Class C waste, because, although the "hottest piece contains more than 1 mCi of Nb-94, the volume of each piece exceeds 0.01 cubic feet (0.00028 m^3)-see paragraph 3.3.2(a). Note in this example, the blade could represent a control rod after the velocity limiter or other segments had been removed.

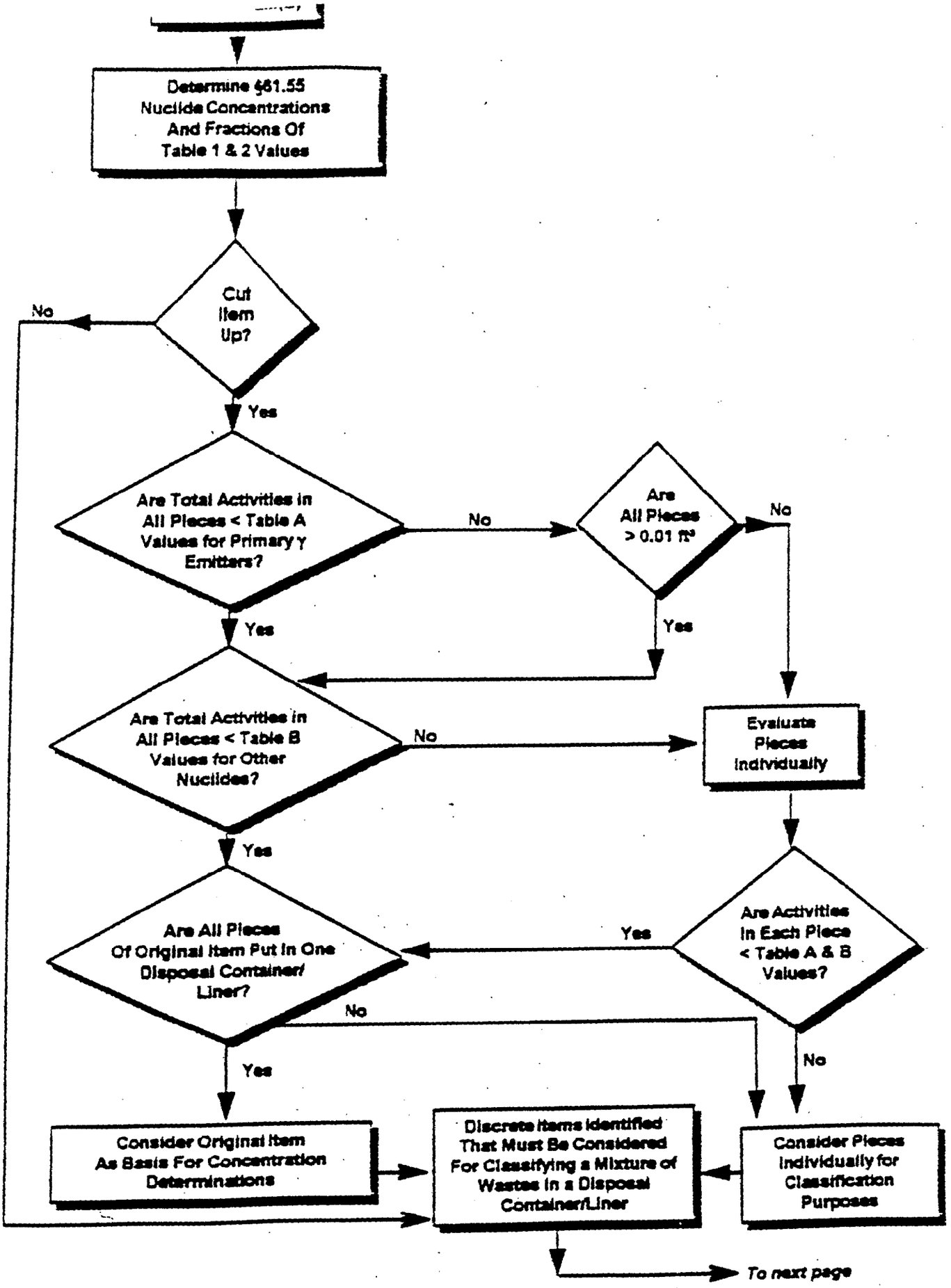
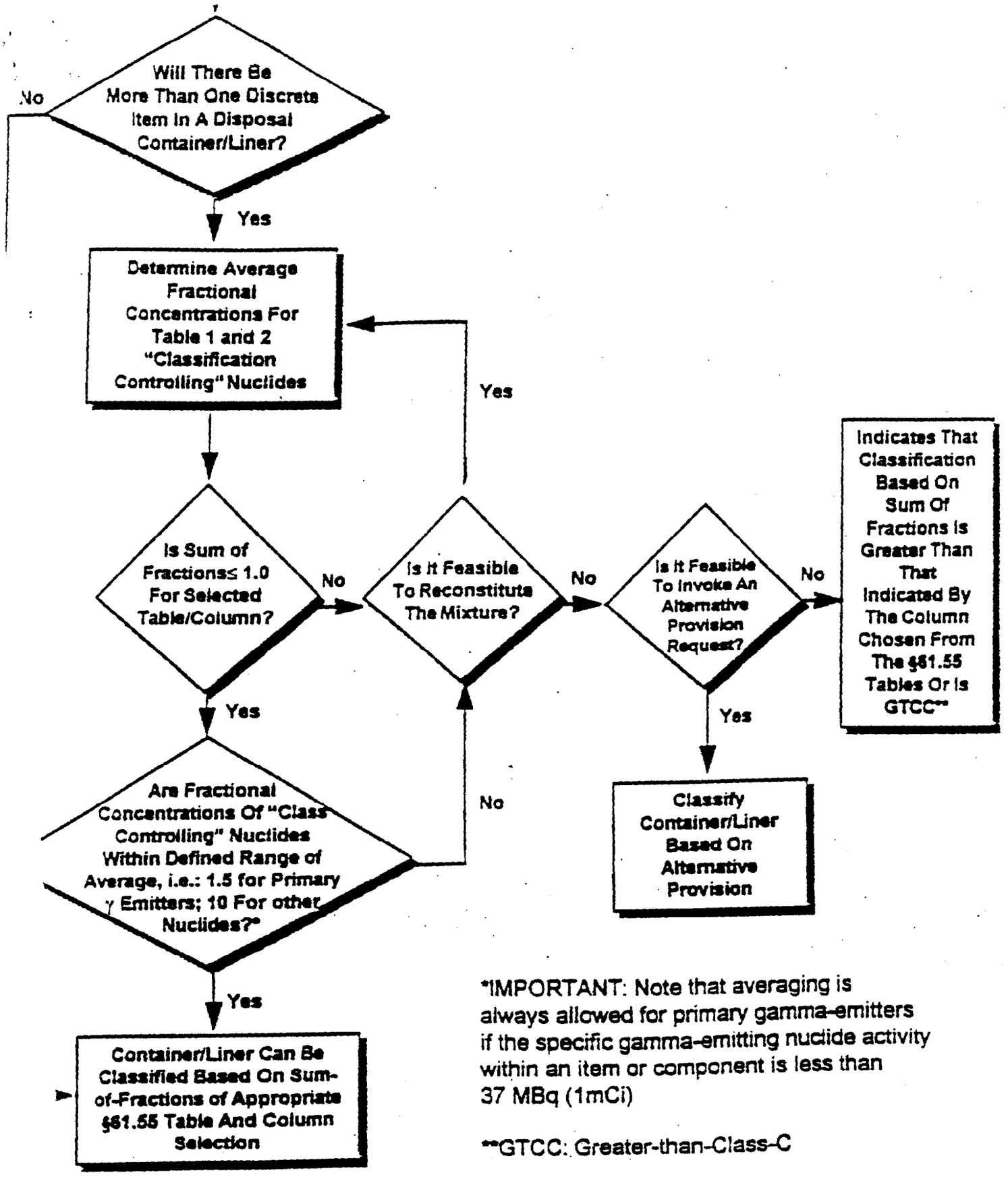


FIGURE 1. LOGIC DIAGRAM FOR CLASSIFYING WASTE COMPRISING ACTIVATED METAL OR COMPONENTS CONTAINING RADIOACTIVITY IN THEIR DESIGN.



*IMPORTANT: Note that averaging is always allowed for primary gamma-emitters if the specific gamma-emitting nuclide activity within an item or component is less than 37 MBq (1mCi)

**GTCC: Greater-than-Class-C

FIGURE 1. (Continued)

Example 3: A liner contains four local power range monitor (LPRM) strings. Note: In actual cases, liners could contain more than this number. Each string has a volume of 0.1 ft^3 (0.0028 m^3) and weighs 50 lbs (22.7 kg). The activity of the principal "classification-controlling" nuclides in each string are shown below (rounded), along with the nuclides concentration expressed as a fraction (frac) of the appropriate 10 CFR 61.55, Table 1 or Table 2, Column 3, concentration values.

	LPRM #1		LPRM #2		LPRM #3		LPRM #4		AVE.
Nuclide	Ci	frac	Ci	frac	Ci	frac	Ci	frac	
Nb-94	0.0004	0.71	0.0003	0.53	0.00035	0.62	0.0005	0.89	0.69
Ni-59	0.12	0.20	0.09	0.15	0.1	0.17	0.13	0.22	0.19
C-14	0.02	0.09	0.015	0.07	0.017	0.08	0.02	0.09	0.08
TABLE 1 TOTAL		1.00		0.75		0.87		1.2	0.96
Ni-63	18.0	0.92	13.5	0.69	15.75	0.81	22.0	1.12	0.89
TABLE 2 TOTAL		0.92		0.69		0.81		1.12	0.89

The strings need to be cut into three pieces for packaging, and this sectioning leads to essentially all of the activity being contained in a piece that has a volume of 0.017 ft^3 (0.00048 m^3) and weighs 8.5 lbs (3.9 kg).

It would be permissible to average the Nb-94 concentration over all four strings since no string contains more than 37 MBq (1 mCi) of Nb-94. Furthermore, all the concentrations of the individual strings are within a factor of 1.5 of the average concentration (i.e., 0.69 x 0.2 Ci/m^3 = 0.14 Ci/m^3). Likewise the concentrations of the other tabulated nuclides are within a factor of 10 of their average concentrations. If the strings were shipped as a whole, the waste would be classified as Class C, since the sum-of-the-Table 1 fractions is 0.96 and the Ni-63 concentration is less than (i.e., 0.89 times) the Class C limit of 7000 Ci/m^3. Although the cutting operation could increase concentrations in the "hottest" piece by about a factor of 6, this sectioning would not affect the classification of the waste since (1) the volume of the "hottest" piece is greater than

0.01 ft^3 (0.00028 m^3); (2) the largest Nb-94 activity in any piece, 0.5 mCi, is less than the 1 mCi value in Table A; (3) the activities of the other nuclides in the "hottest" piece are less than Table B values; and (4) all pieces of the sectioned string are placed in the same disposal container.

3.4 Contaminated materials

Contaminated materials typically involve components or metals on which radioactivity resides near the surface in a fixed or removable condition. Classification of individual items may be determined by representative swipes or radiation survey measurements from which the total activity of radionuclides may be estimated through the use of scaling factors. In these cases, the volume or weight of the contaminated item should be the total weight or displaced volume of the item (i.e., major void volumes subtracted from envelope volume).

Mixtures of contaminated materials in a disposal container are permissible. In these situations, the total activity of contained radionuclides may also be determined by representative swipes or radiation survey measurements of the container's contents. The volume or weight of the mixture should be the total weight or displaced volume of all the material contributing to the mixture.

In determining the classification of a mixture of contaminated materials, it is always permissible to conservatively base the mixture classification on the highest classification associated with any piece, section, or component within a disposal container. It is also permissible, under the following constraints, to average concentrations of the radionuclides listed in 10 CFR 61.55, Table 1 and Table 2, over contents of the disposal container. Again, because of the potential non-homogeneity of the waste, the classification of the combined waste may be affected by whether the contaminated waste contains the primary gamma-emitting nuclides (e.g., typically, Co-60 and Cs-137/Ba-137m). For the purpose of applying the guidance under these paragraphs, a component may be considered to be that portion of an original component that is placed in the disposal container being classified. Although components may be comprised of multiple sections or pieces to effectuate packaging, the component (not the pieces or sections thereof) is the discrete item to which this guidance applies.

In determining the classification of the container, one or more of the following paragraphs may apply.

3.4.1 Averaging involving primary gamma-emitters

For the purpose of classifying a mixture containing the primary gamma-emitters (typically Co-60 and/or Cs-137/Ba-137 contamination), for which these nuclides dictate the classification of the waste, their individual nuclide concentrations may be based on the volumetric-averaged concentration of the combined contaminated materials, provided that the concentrations associated with the individual items of the mixture in the disposal container are within a factor of 1.5 of the respective averaged concentration value for each nuclide. Averaging is always allowed for a primary gamma-emitting nuclide if its activity on a contaminated item is less than 37 MBq (1 mCi).

3.4.2 Averaging of sections or pieces of larger components containing the primary gamma-emitters

Individual sections of pieces of larger components that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items if:

(a) the volume of the piece or section is less than one-hundredth of a cubic foot (0.01 ft^3) or 0.00028 cubic meters (0.00028 m^3) -- such a piece will typically weigh less than 10 pounds (10 lbs) or 4.54 kilograms (4.54 kg), and

(b) the specific nuclide activity contaminating the material or component would be greater than the respective values shown in Table A.

3.4.3 Averaging involving radionuclides other than primary gamma-emitters

For the purpose of classifying a mixture, the concentrations of all the 10 CFR 61.55 tabulated radionuclides in the disposal container, other than the primary gamma-emitters, may be based on the volumetric- or weight-averaged concentrations of the combined materials. In this case, all the concentrations of the "classification-controlling" individual nuclides within all the contaminated items should be within a factor of 10 of their respective averages over all items in the mixture.

3.4.4 Averaging involving sections or pieces of larger contaminated items or components containing other than primary gamma-emitters

Individual sections or pieces of larger contaminated items or components in a disposal container that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items if the specific radionuclide activity on the contaminated piece or section exceeds the appropriate value in Table B.

3.4.5 Mixtures containing multiple radionuclides

For contaminated components or metal containing combinations of tabulated nuclides, the sum-of-the-fractions rule described in 10 CFR 61.55(a)(7) would apply. This rule involves the summing of the fractions of the appropriate 10 CFR 61.55, Table 1 or 2 concentration values, as described in §§61.55(a)(7). The sum of-the-fractions rule could involve summing the fractions of the appropriate §61.55 Table 1 or Table 2 concentration values associated with the primary gamma-emitting nuclides and the fractions of tabulated concentrations associated with the other nuclides. The respective fractions contributing to the sum can be calculated using the "highest concentration" existing in any item within the mixture or, if applicable, the concentration determined using the "averaging" methods previously described.

Independent of the method chosen, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the mixture of contaminated materials must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of the mixture of contaminated materials is based on the volumetric- or weighted-averaged nuclide concentrations of the disposal container contents, as allowed above, the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analyses. It is generally expected that this record or analyses, in and of itself, should be sufficient to show that the averaging of concentrations over all the contaminated material in a disposal container was undertaken under the provisions of this position.

3.5 Mixing of cartridge filters

The classification of cartridge filters should be based on the nuclide activity contained on the filter divided by the displaced volume (interstitial space within the filters may be included) or weight of the filter. Because of the typical distribution of activity within cartridge filters, the envelope volume would generally be expected to be an appropriate volume for determining filter classifications.

Mixing of multiple cartridge filters in a disposal container or liner is permissible. In determining the classification of the multiple filters, it is always permissible to conservatively base the classification on the highest classification associated with any single filter. It is also permissible, under the following constraints, to average the concentrations of radionuclides listed in 10 CFR 61.55, Table 1 and Table 2. Because of the potential non-homogeneity of the filters, the classification of the combined filters may be affected by whether the waste contains the primary gamma-emitting nuclides (typically, Co-60 or Cs-137/Ba-137m). However, the classification of many higher class cartridge filters could be controlled by C-14 or transuranic concentrations. In determining the classification of a container of filters, one or more of the following paragraphs may apply.

3.5.1 Averaging involving primary gamma-emitters

For the purpose of classifying multiple cartridge filters containing the primary gamma-emitters (i.e., if these nuclides dictate the classification of the waste), their individual nuclide concentrations may be based on the volumetric-averaged concentration of combined filters, provided that the concentrations within the individual filters of the mixture in the disposal container or liner are within a factor of 1.5 of the respective averaged concentration values of each nuclide. This factor of 1.5 does not apply if the classification of the combined filters, as a result of other nuclides, is higher than the class derived from the primary gamma-emitter concentrations.

3.5.2 Averaging involving radionuclides other than primary gamma-emitters

For the purpose of classifying multiple cartridge filters, the concentrations of all the 10 CFR 61.55 tabulated radionuclides in the disposal container or liner, other than the primary gamma-emitters, may be based on the volumetric- or weight-averaged concentrations of the combined materials. In this case, all the concentrations of the "classification-controlling" individual nuclides within all the individual filters should be within a factor of 10 of their respective averages over all filters in the mixture.

3.5.3 Mixtures containing multiple radionuclides

For cartridge filters containing combinations of tabulated nuclides, the sum-of-the-fractions rule described in 10 CFR 61.55(a)(7) would apply. For cartridge filters, this rule could involve summing the fractions of the appropriate 10 CFR 61.55, Table 1 or Table 2 concentration values associated with the primary gamma-emitting nuclides and the fractions of tabulated concentrations associated with the other nuclides. The respective fractions contributing to the sum can be calculated by using the "highest concentration" associated with any filter or, if applicable, the concentration determined by using the "averaging" methods described previously.

Independent of whether the "highest concentration" or "averaging" method is used to classify multiple filters in a disposal container/liner, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the mixture of filters must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of the mixture of filters is based on the volumetric- or weight-averaged nuclide concentrations of the disposal container/liner contents, as allowed above, the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analyses. It is generally expected that this record or analysis, in and of itself, should be sufficient to show that the averaging of concentrations over all the contents in the disposal container/liner was undertaken under the provisions of this position.

3.5.4 Illustrative example

Example: A liner contains four cartridge filters. Note: In actual cases, more than this number could be contained in a liner. The filter volumes, weights, and principal "classification-controlling" nuclide activities are shown below (rounded), along with the nuclide's concentration expressed as a fraction (frac) of appropriate Table 1 concentration value. A Cs-137 concentration is also presented.

	Fuel Pool				Reactor Coolant			
	Filter #1		Filter #2		Filter #1		Filter #2	
Volume (m^3)	0.024		0.024		0.0127		0.0127	
(ft^3)	0.85		0.85		0.45		0.45	
Weight (kg)	9.08		9.08		4.09		4.09	
(lbs)	20		20		9		9	
Nuclide	Ci	frac	Ci	frac	Ci	frac	Ci	frac
C-14	0.01	0.052	0.009	0.047	0.005	0.05	0.002	0.02
Pu-241	0.008	0.25	0.007	0.22	0.01	0.71	0.004	0.28
Transuranic	0.0004	0.44	0.0003	0.33	0.0005	1.24	0.0002	0.49
10 CFR 61.55 Table 1 Total		0.74		0.60		2.00		0.79
Cs-137 =	$\frac{\text{concentration}}{1.5 \times 10^{-2}\ Ci/m^3}$		$\frac{\text{concentration}}{1 \times 10^{-2}\ Ci/m^3}$		$\frac{\text{concentration}}{1 \times 10^{-1}\ Ci/m^3}$		$\frac{\text{concentration}}{4 \times 10^{-2}\ Ci/m^3}$	

The Cs-137/Ba-137m activity in all the filters is sufficiently small such that the classification of the filters will not be determined by this gamma-emitting nuclide. Similarly, other nuclides to which 10 CFR 61.55, Table 2 values may apply have not been listed since their values will not affect cartridge filter classification. Thus, the four filters listed could be placed in a single disposal container/liner, since all the listed nuclide concentrations are within an order of magnitude of the averaged concentrations. The sum-of-the-fractions for the three nuclides would be: C-14, (0.04) + Pu-241, (0.32) + Transuranic (TRU), (0.53) = 0.89, indicating that the multiple filters could be classified as Class C waste.

3.6 Waste in high-integrity containers (HICs)

In the case of cartridge filters or other discrete item waste stabilized by emplacement within HICs, the volume or weight used to determine waste classification should be calculated over the displaced volume (interstitial space within the filters may be included - envelope volume may be appropriate) or

weight of the cartridge filter or discrete item itself, rather than the gross volume or weight of the container. Similarly, the volume and mass considered for purposes of waste classification of dewatered ion-exchange resins, filter backwashes, and filter media placed into HICs should be the volume and mass of the contained waste. In both these cases, disposal in a HIC is not considered to alter the as-buried concentrations of radioactivity.

3.7 Encapsulation of solid material

For routine wastes such as filters, filter cartridges, or sealed sources centered in an encapsulated mass, classification may be based on the overall volume of the final solidified mass, provided that: (1) the volume and attributes of the encapsulated waste comply with the constraints established in Appendix C of this technical position; (2) the solidified mass meets the waste form structural stability criteria of 10 CFR 61.56 for Class B and Class C waste; and (3) the disposal unit containing the encapsulated mass is segregated from disposal units containing Class A wastes, that do not meet the structural stability requirements in 10 CFR 61.56(b). Under the above provisions, additional protection is provided through the shielding, lack of dispersibility, or identifiability of the encapsulated mass and, for Class C encapsulated waste, by the land disposal facility operational requirements in 10 CFR 61.52(a)(2). This additional protection has been considered in the classification position developed in Appendix C and has been balanced against the hypothetical radiological impact caused by potential interactions between assumed intruders and the encapsulated mass.

3.8 Mixing of dissimilar waste streams (different waste types)

Classifications may also be required for situations involving a mixture of miscellaneous waste materials -- e.g., situations in which contaminated valves, piping, or similar components are placed in containers mixed with other trash; or miscellaneous trash or components are mixed with other radioactive materials such as resins or filters. In such cases, because of potential differences in waste interactions with the disposal environment, waste classification involving averaging the total activity over the total volume or mass of the waste in the container would be accepted, if the classification of the mixture is not lower than the highest waste classification of any individual components of the mixture. This provision does not apply to small concentrated microcurie sources (<3.7 MBq (100 μCi)) of waste such as check

sources or gauges that may be mixed with contaminated trash waste streams. The activity of such check sources or gauges may be averaged over the trash volume. Other classification practices may be determined to be acceptable under the "Alternative provisions" paragraph that follows.

3.9 Alternative provisions

Under 10 CFR 61.58, the Commission, on request, may authorize other 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.

Alternatives to the determination of radionuclide concentrations for waste classification purposes, other than those defined in this technical position, may be considered acceptable. For example, the physical form of certain discrete wastes (e.g., activated metals) may be such that intruder exposure scenarios, other than those used to establish the values in Tables 1 and 2 of 10 CFR 61.55, may be appropriate. A case in point could be the disposal of a large intact activated component filled with a structurally stable medium (e.g., cement), or enclosed in a massive robust container capable of meeting structural stability requirements. A request that demonstrates, with reasonable assurance, that the performance objectives in Subpart C of 10 CFR Part 61 are met, may be used to justify that the waste is acceptable for near-surface disposal. Alternatives would require the approval of, or otherwise be authorized by, the NRC or Agreement State regulatory agency. In some cases (e.g., if the approaches in this technical position had been incorporated as disposal facility license conditions), the disposal facility may need to apply for a license amendment from the NRC or Agreement State regulatory agency, to incorporate the alternative provision into its license.

Table C provides a summary of the primary aspects of the aforementioned guidance.

Table C

Volumes and Masses for Determination of Concentration

Waste Type	Allowable Classification Volume or Mass
Contaminated trash or soil	Reasonable fill volume of container/mass of waste (<10% void)*
Absorbed liquids	Volume/mass of liquid before absorption
Solidified liquids	Volume/mass of solidified mass
Solidified ion-exchange resins	Volume/mass of solidified mass**
Dewatered ion-exchange resins in HICs or liners	Displaced (bulk) volume (interstitial space may be included)/dewatered mass of ion-exchange resins
Filter cartridges in HICs or liners	Displaced volume (interstitial volume may be included) or envelope volume/mass of filters*
Activated components, components containing radioactivity in their design, or contaminated materials	Full density volume/(major void volumes subtracted from envelope volume)/ mass of components*
Encapsulated filter cartridges or sealed sources	Volume/mass of solidified mass when encapsulated in accordance with the guidance provided in Appendix C in this expansion of the technical position

* Mixtures of waste streams subject to additional guidance defined in text.

** If homogeneity maintained in solidified mass.

* * * * * *

APPENDIX C

POSITION ON ENCAPSULATION OF SEALED SOURCES AND OTHER SOLID LOW-LEVEL RADIOACTIVE WASTES

Encapsulation can mitigate dispersion of waste and can also provide additional shielding to limit external radiation fields. If provided to meet the stability criteria of 10 CFR 61.56(b) and coupled with the technical requirements for land disposal facilities in subpart D of 10 CFR Part 61 (specifically, 10 CFR 61.52), encapsulation will limit the impacts from both: (1) the direct exposure, inhalation, and ingestion pathways associated with potential intruder-waste interactions; and (2) the potential exposure pathways, to individual members of the public, involving groundwater and agricultural products.

The amount of credit allowed for encapsulation, though, needs to be limited so that extreme measures cannot be taken solely for the purposes of dilution. To be consistent with the U.S. Nuclear Regulatory Commission's policy on volume reduction and to limit extremely large "point sources" of radioactivity in the disposal site, generally acceptable values for minimum and maximum encapsulated waste volumes and masses, nuclide activities, and radiation levels are established.

These generally acceptable bounding conditions are as follows:

(1) A <u>minimum</u> solidified volume or mass for encapsulation should be that which can reasonably be expected to increase the difficulty of an inadvertent intruder moving the waste by hand, following the loss of institutional control over the disposal site. This minimum size or weight should preclude any significant movement without the assistance of mechanical equipment.

(2) A <u>maximum</u> solidified volume or mass for encapsulation of a single discrete source (from which concentrations are determined) should be 0.2 m^3 or 500 Kg (typical 55-gallon drum). Larger volumes and masses may be used for encapsulation of single sources but, in general, unless a specific rationale is provided, no credit beyond the volume or mass indicated should be considered when determining waste concentrations. Encapsulation of multiple sources (e.g., filters) in larger volumes may be considered acceptable under the Alternative provisions paragraph.

Note: The bounding volumes and weights in (1) and (2) will ensure that the potential radiological impacts from encapsulated, single discrete source disposals are within the envelope of impacts that would be calculated if the radioactivity were homogeneously distributed throughout the encapsulating media.

(3) A maximum amount of gamma-emitting radioactivity (e.g., Cs-137/Ba-137m, Nb-94) or radioactive material generally acceptable for encapsulation is that which, if credit is taken for a 500-year decay period, would result in a dose rate of less than 0.2 μSv/hr (0.02 mrem/hr) on the surface of the encapsulating media (refer to footnote 1, following page). The

calculation to determine compliance with this criterion may consider the minimum attenuation factor provided by the shielding properties of the encapsulating media but, in general, this factor should not exceed an attenuation factor that would be provided by 15 inches of concrete encapsulating material (refer to footnote 2). Furthermore, the maximum Cs-137/Ba-137m gamma-emitting generally acceptable for encapsulation in a single disposal container is 1.1 TBq (30 Ci) (refer to footnote 3 below).

(4) A maximum amount of any radionuclide that should be encapsulated in a single disposal container intended for disposal at a commercial low-level waste disposal facility is that which, when averaged over the waste and the encapsulating media, does not exceed the maximum concentration limits for Class C waste, as defined in Tables 1 and 2 of 10 CFR 61.55 (refer to footnote 4, below).

(5) In all cases when a discrete source of radioactive solid waste is encapsulated, written procedures should be established to ensure that the radiation source(s) is reasonably centered within the encapsulating medium.

Footnotes

1. Presuming the inadvertent intruder has contact with the encapsulated waste as generally defined in the intruder-agricultural scenario (reference NUREG-0945), this dose rate would result in an annual exposure of less than one-tenth of that which would be received if the radioactivity were homogenized over a soil volume equivalent to the encapsulating medium. This factor of 10 takes into consideration the possibility that the intruder may be exposed to both: (1) other encapsulated waste that may be excavated from the disposal trenches without mixing with uncontaminated cover material, and (2) other homogenized waste.

2. The 15 inches of concrete shielding is that necessary to ensure that an encapsulated 1.1 TBq (30 Ci) source of Cs-137/Ba-137m could satisfy the 0.2μSv/hr (0.02 mrem/hr) dose criteria. Additional shielding thicknesses from the encapsulating or disposal unit materials could be expected to be in existence after 500 years, but because of uncertainties about shielding orientations and effectiveness after this time period, no greater credit is considered generally appropriate. Furthermore, absent any shielding, intruder doses would still be expected to be similar to doses that would be received from homogeneous waste at concentrations permitted in 10 CFR 61.55.

3. The 1.1 TBq (30 Ci) for Cs-137/Ba-137m results from the application of the dose rate and shielding criteria in bounding condition 3.

4. Reasserting the applicability of Tables 1 and 2 of 10 CFR 61.55 emphasizes that, for alpha- or beta-emitting radionuclides, encapsulation under bounding conditions 1 through 3 does <u>not</u> provide an exemption to the classification tables in the regulations. As a result, the largest activity of a transuranic nuclide, other than Pu-241 and Cm-242, that is

generally acceptable for encapsulation in 0.2 m^3 is about 1.1 GBq (30 mCi), presuming the density of the encapsulating mass is 1.3 g/cm^3. For determining mass-based concentrations, it is generally acceptable to take credit for the actual density of the material, if the density is less than 2.5 g/cm^3.

ANALYSIS OF AND RESPONSE TO COMMENTS ON
"CONCENTRATION AVERAGING AND ENCAPSULATION TECHNICAL POSITION"
Revision Issued on September 16, 1993

On September 22, 1993, the Nuclear Regulatory Commission noticed in the Federal Register the availability of a proposed revision to the staff technical position on concentration averaging and encapsulation for low-level waste intended for licensed land disposal facility (58 FR 49333). The revision represented a modification and expansion of an earlier proposal that was noticed in the Federal Register on June 22, 1992 (57 FR 29105) and was developed after considering the comments received on this initial proposal. Comments on the revision were again solicited and, in response, 13 comment letters were received. These responses included four from nuclear utilities and one from their association, the Edison Electric Institute (EEI), one from a citizens group, one from a disposal facility operator, two from State health association, one from a firm in the waste classification field, and two from the U.S. Department of Energy (one stating that their comments would not be developed before the requested date). These letters raised a number of issues ranging from general policy concerns to specific comments on how the position cold be structured to facilitate its use.

1. COMMENT: A general policy comment raised by the utility commenters, the EEI, the trade association, and the Department of Energy, was that the limitation on averaging, defined in the position, are not justified within the contest of the regulations in 10 CFR Part 61. This opinion was also expressed by commenters on the initial June 22, 1992 proposal. These commenters stated that the averaging positions are arbitrary, do not have a health and safety basis, would increase costs and occupational exposures, would require changes in current practices, and would result in higher waste classifications. The commenters believed that the concentration values tabulated in the regulations, through which waste classifications are determined in the regulations, through which waste classification are determined, were derived in a manner that conservatively considered waste concentrations over a disposal trench. As a result, these commenters believed that classification based on averaging of waste activity over the contents of a waste package should be allowed. Further, the DOE stated their belief that, although the Part 61 performance objectives call in a general way for protection of the inadvertent intruder, the intruder was never the driving force behind the Part 61 rule. The DOE comments suggested that, in the Part 61 Environmental Impact Statement (EIS), the NRC determined that it would be ludicrous to assume that an inadvertent intruder would construct houses among excavated, structurally stable wastes. As a result, an "intruder-discovery" scenario was postulated.

The comments from the citizens group stated an opposite view in that it found the position unacceptable because the position would allow greater-than-Class C (GTCC) waste to be classified as Class C waste. The comments from the Department of Health also expressed concern that GTCC waste could be disposed of in a near-surface low-level waste facility, and suggested that there not be a movement of waste from one class to another. The comments from the Department of Environmental Conservation expressed support for the explanation on waste classification, but pointed out that its State regulations are more restrictive than the guidance with regard to absorbed liquids.

RESPONSE: A response to these general policy comments was attempted in the "Analysis Of and Response To Comments" that was appended to the September 16, 1993 reissued position. The staff does not take issue with the scenarios in the EIS, as described by DOE. The assessment of radiological impacts in the EIS, as described by DOE. The assessment of radiological impacts in the EIS did indeed consider a broad range of scenarios, and the development of the technical position followed a similar approach in defining the concentration averaging and encapsulation positions for "discrete" wastes that were not addressed in detail in the EIS. The staff believes that discussions in the final EIS, for example in Section 5.3.5, suggest that the NRC recognized the need for further classification guidance and/or site inventory constraints, when specific disposal sites and the composition of specific waste streams were being considered.

Notwithstanding this basis, the staff also emphasized two other major points in the September reissuance of the technical position: (1) the technical position reflects a subset of practices that are generally considered acceptable under the envelope of safety defined in the EIS, and (2) the practices defined in the position were intended to represent a subset of those likely to be generally accepted by the Agreement States. To accomplish this latter purpose, the staff has developed the technical position in cooperation with the E-5 Committee on Radioactive Waste Management of the Conference of Radiation Control Program Directors (CRCPD). Although the objective is to facilitate consistent practices on a national basis, the staff recognized that variances could occur. On this point, it should be noted that the EIS indicates that within the context of the classification provisions stated in the regulations, Agreement States have imposed waste acceptance criteria on their sites that vary from the positions assumed in the EIS. And, as the Department of Environmental Conservation commenter indicated, some minor differences between the guidance presented in the technical position and State regulation and guidance could occur.

On a more technical basis, the material in the Appendix is provided to further describe the rationale used to develop the criteria in the technical position. In all cases, the approach taken was based on demonstrating compliance with the intruder dose criterion that was used to generate the tabulated concentration values in the regulations. Thus, in response to the comments from the citizens group and the Department of Health, the staff believes that the averaging practices specified in the position always result in a waste classification that is at least as high, if not higher, than that indicated by the concentration tables in the regulations, based on the average concentrations over a disposal container (or waste Package).

2. COMMENT: Several commenters stated their belief that the position was unjustifiable complex in considering the averaging of the primary gamma-emitters (i.e., Co-60, Nb-94, and Cs-137) vis-a-vis the other nuclides tabulated in the regulations. The inclusion of activity ranges, minimum activity, and size criteria were cited as typical examples of these complexities. These commenters believed that the complexities were especially unwarranted, given the fact that the position carries on authority with the Agreement States. The citizens group commenter suggested a simpler approach through which the waste classification of a mixture of components would not be

lower than the highest waste classification of any individual component of the mixture.

RESPONSE: For those desiring to take advantage of certain acceptable concentration averaging positions (typically, those involving discrete activated materials or metals, or contaminated items), the technical position could be considered complex. Much of the current complexity, when compared to the originally proposed June 26, 1992 position, is associated with the classification of pieces of larger components. The staff decided to address these cases based on the recommendations received from some of these commenters on the initial version of the technical position. The need to differentiate between primary gamma-emitters and the other nuclides, listed in the tables in §61.55, results from the fact that the averaging positions in the technical position address "discrete" wastes within the envelope of safety defined in the EIS for wastes that were assumed to be indistinguishable from soil at the time the intruder was presumed to interact with the waste. The foundation for the practices defined in the technical position in based on ensuring compliance with the performance objectives in the regulations (most specifically §61.42). The appendix material has been provided to indicate the rationale and assumptions behind the exposure scenarios used to achieve this demonstration of compliance.

As discussed in response to the first comment, the staff recognizes that the Agreement States and Compacts are not required to accept NRC's concentration averaging positions as expressed through guidance documents (including those positions that define the breakpoint between what constitutes waste for which the States are responsible for disposal (i.e., Class C or less) and that waste for which disposal responsibility rests with the Federal government (i.e., GTCC waste)); however, the staff believes that approaching nationwide conformity sufficient to carry out the directives contained in the Low-Level Radioactive Waste Policy Amendment Act of 1985 (P>L> 99-240), is best achieved by defining a subset of acceptable concentration averaging and encapsulation practices in cooperation with State regulatory authorities through the CRCPD.

CLARIFICATIONS INCORPORATED AS A RESULT OF COMMENTERS' SUGGESTIONS

As a result of commenters' suggestions, the following clarification and editorial changes have been made to the final technical position: (1) a numbered index system has been included to assist the reader in keeping track of the specific waste type for which averaging guidance is being provided; (2) consistent terminology is used in referring to "discrete" items and "primary gamma-emitters"; (3) it has been clarified that the record of analyses which documents the licensee's use of concentration averaging and encapsulation practices defined in this technical position, should generally be sufficient, in and of itself, to show that the averaging of concentrations was not undertaken solely to lower the classification of any specific waste in a disposal container; (4) a statement has been added to the introduction to the technical position indicating that it is intended that the "Alternative provisions" paragraph in the position could be used, if necessary, to preclude the need to reclassify waste material packaged and classified prior to the issuance of this position, if the waste was classified in accordance with accepted practices at the time of packaging, provided that disposal of such

waste can be conducted safely and in accordance with 10 CFR 61; (5) a statement has been added to indicate that, because of the typical distribution of activity within cartridge filters, (including the fact that higher classifications are determined over the weight of the waste), the filter's envelope volume can be used to calculate volumetric concentrations; and (6) it has been further clarified in Appendix C that the specified maximum solidified volume or mass for encapsulation is principally directed at radioactive material in a single discrete source. Averaging of the summed activity of a number of discrete sources solidified in a larger volume or mass than that associated with a 55 gallon drum may be determined to be acceptable under the provisions described in the "Alternative provisions" paragraph.

COMMENTS NOT ADDRESSED IN THE TECHNICAL POSITION

3. COMMENT: Several commenters raised issues that were judged to be outside the scope of the technical position or made suggestions that were not incorporated into the technical position. The citizen group commenter, for instance, suggested that NRC should reconsider the waste classification scheme in 10 CFR Part 20. Along similar lines, the DOE commented that the classification limits for some nuclides important to classifying metals (e.g., Ni-59 and Ni-63) were calculated using older ingestion dose calculational methods that are very conservative compared to current methods.

RESPONSE: The technical position has been developed to be consistent with existing regulations (i.e., the staff's intent was to define concentration averaging and encapsulation practices that are consistent with the underlying rationale expressed in the EIS supporting the Part 61 rulemaking). In response to a recent petition for rulemaking (59 FR 17052, April 11, 1994), the NRC provided the rationale for deciding that the change to the public dose limits did not require reconsideration of the waste classification scheme.

4. COMMENT: On matters more specifically directed at the details of the position, two commenters suggested that further clarification was needed on what constitutes a "homogeneous" waste type. One commenter suggested that the term, which refers to the distribution of activity over a waste type, be replaced by the phrase, "volume distributed". The other commenter suggested that a specific listing of waste types be provided that could be considered "homogeneous".

RESPONSE: The terminology, "homogeneous for purposes of waste classification", is defined in the introductory discussion in paragraph C.3. Within the context of this definition, the staff believes that either term of reference could have been used. In most cases, specification of a "waste type" (e.g., activated metal) should be sufficient to establish whether a waste can be considered "homogeneous" for purposes of waste classification, and the technical position provides several examples of homogeneous waste types. Some waste types, however, such as cartridge filters, could conceivably be considered either "discrete" or "homogeneous" depending on specific cartridge filter characteristics expected within the disposal environment at the time interaction with the intruder is presumed. Treatment as a homogeneous waste type would generally be expected.

5. COMMENT: The citizens group commenter observed that a statement in the revised position indicated that the position had been expanded to address current practices and questioned whether the practices included in the position were being judged to be acceptable simply because they were currently accepted.

RESPONSE: As discussed previously, and in the analysis of and response to comments on the June 22, 1992 proposal, the acceptability of a concentration averaging or encapsulation practice has been judged on the basis that the practice does not compromise the §61.42 performance objective for protection of individuals from inadvertent intrusion. The staff believes that appropriately conservative hypothetical exposure scenarios have been used in making this determination.

6. COMMENT: A few commenters believed the position should define acceptable concentration averaging positions for large activated metal pieces.

RESPONSE: Because the specifics pertaining to volumes, activities, and activity distributions can be important to the acceptability of a specific averaging practice, the staff believes that these cases should be considered through the "Alternative provisions" paragraph of the position.

7. COMMENT: A number of commenters stated that the position would force all cartridge filters in a container to be individually characterized and classified, leading to unnecessary occupational exposures an costs.

RESPONSE: The staff believes that the position does not dictate such an approach. Under the "General Criteria" in paragraph C.1 in the unrevised part of the Technical Position on Waste Classification, dated May 11, 1983, a number of acceptable methods were described for determining concentrations for classification purposes. The staff believes that knowledge regarding the activity on individual filters can be used to estimate concentrations of nuclides for classification purposes and that such methods are already used to comply with the "manifesting" provisions of the regulations.

BASES FOR CONCENTRATION AVERAGING AND ENCAPSULATION GUIDANCE FOR CLASSIFICATION OF DISCRETE (HETEROGENEOUS) WASTES REFLECTED IN REVISED BRANCH TECHNICAL POSITION

Background

In the environmental impact statement (EIS) supporting the promulgation of 10 CFR Part 61, the concentration values that appear in Tables 1 and 2 of §61.55 were based on potential exposures to inadvertent intruders. The intruder dose calculations included a scenario which presumed that the intruder took up residence on a closed disposal site and exhumed waste from its disposed location. This exhumed waste was assumed to be indistinguishable from soil and, as a result, the intruder was conservatively assumed to be unaware of his/her interaction with previously disposed radioactive waste.

The scenario, however, did recognize that, as the intruder exhumed the waste, the contaminated soils containing varying types and concentrations of radioactive contamination were likely to be thoroughly "homogenized". Furthermore, the homogenized waste would be mixed with clean interstitial and cover material. In effect, the "as disposed" concentration of radioactive material was assumed to be typically reduced by a factor of 8. In addition, in considering the postulated exhuming of Class C waste, it was recognized that this waste would not only be difficult to contact, even after 500 years, but in the postulated exhumation process, would also likely be mixed with lower activity waste streams. These considerations resulted in the application of a factor of 10 reduction to the projected intruder doses from Class C wastes.

Technical Position Bases For Concentration Averaging of Discrete (Heterogeneous) Waste

A major intent of the revised Technical Position on Concentration Averaging and Encapsulation is to define positions for the disposal of discrete wastes or mixtures of such wastes that fall within the "envelope of safety" defined in the EIS. The primary consideration in this effort was to ensure that potential exposures to the "contaminated soil" waste exhumed in the EIS scenario would be equivalent to potential exposures from the postulated exhuming of discrete wastes. Four specific discrete waste forms were addressed: (1) encapsulated sealed sources, (2) neutron-activated materials or metals, or components incorporating radioactive material into their designs, (3) contaminated materials, and (4) cartridge filters. These waste forms were further subdivided to consider the specific nuclides identified in the 10 CFR 61.55 tables: (1) the primary gamma-emitters (Co-60, Nb-94, and Cs-137/Ba-137m), and (2) other nuclides. This latter subdivision was considered because "hot spots" of gamma activity may be more significant to potential intruder doses than "hot spots" associated with the other nuclides.

Disposal of gamma-emitting sealed sources

The implicit dose criterion for the primary gamma-emitting nuclides, from

which the Table 1 and 2 concentration values of §61.55 are derived, is 500 mrem/year. This is the projected dose that an intruder would be calculated to receive if waste were exhumed and dispersed according to the EIS intruder-agricultural scenario. For example, assuming the nuclide of interest is Cs-137, the EIS methodology would presume that waste initially containing Cs-137 at the Class C upper bound concentration of 4600 Ci/m^3 could be exhumed and dispersed five hundred years after LLW site closure. Considering the scenario concentration reduction factors and radioactive decay, the intruder is presumed to be exposed to an infinite half-plane source of Cs-137 at a concentration of about 540 pCi/cm^3 or 340 pCi/g; that is,

$4600\ Ci/m^3 \times 10^6\ pCi/cm^3/Ci/m^3 \times (9.4 \times 10^{-6}$ decay factor) $\times$ (0.125 interstitial and cover mixing factor) $\times$ (10^{-1} intrusion likelihood and mixing factor with lower activity waste) = 540 pCi/cm^3 or 340 pCi/g @ $1.6 g/cm^3$.

An intruder exposed to this infinite half-plane source would receive a dose of about 500 mrem in a year presuming a scenario-equivalent unshielded exposure of about 2360 hours/year.

The encapsulation policy is based on two principal considerations: (1) At 500 years, the sealed (point) source (unencapsulated) should not reasonably result in a dose of 500 mrem/year, even if scenarios other than intruder-agricultural (e.g., handling) are considered, and (2) If the source is exhumed in its encapsulated state, the intruder should not receive an exposure greater than 500 mrem/year, recognizing that the intruder could be exposed to other exhumed waste or other sealed sources.

Application of the first consideration required the definition of an appropriate exposure scenario. The scenario chosen presumes that intruder interaction with the source can be reasonably bounded by evaluating exposure at one meter for a period of 2360 hours/year. This scenario, although more conservative than the pathways evaluated in the intruder-agricultural scenario, is considered a reasonable surrogate to conservatively address the potential for a wide range of potential "handling" scenarios. Application of these scenario assumptions, with the 500 mrem/yr dose criterion, results in the determination that a Cs-137 source of about 650 μCi could potentially be available to the intruder, 500 years after disposal. This is equivalent to a 65 Ci source at time of disposal.

To conservatively address the second consideration, a criterion of 50 mrem/year or 0.02 mrem/hr for 2360 hours was conservatively assigned to the surface of the encapsulated sealed source. This factor of 10 reduction in the dose criterion, and the point of measurement, were incorporated into the analysis to account for the fact that the intruder could be exposed through other than the intruder-agricultural scenario, and to additional exhumed waste containing the same radionuclide. In this case, however, it was considered reasonable to take credit for the shielding (but not the structural integrity) of the encapsulating material (approximately 15 inches that would be available from encapsulations in a 55 gallon drum). For shielding purposes, this is the largest amount of shielding that is presumed to be effective, 500 years after

disposal. Under these constraints, the second criterion would allow the activity of an encapsulated Cs-137 source to be about 300 μCi at 500 years or 30 Ci at the time of disposal.

Since both the above considerations led to approximately the same source activity constraint, and no practical reason could be put forward to justify selection of the somewhat higher criterion, the technical position includes a 30 Ci bound on the activity of a Cs-137 sealed source, that can be encapsulated and disposed of as Class C waste in a near-surface disposal facility. If applied to a point source of Nb-94, the activity constraint both at disposal and at 500 years would be about 40 μCi.

Disposal of alpha/beta emitting sealed sources

When considering potential exposures from the postulated exhumation of alpha or beta emitting nuclides, the controlling scenarios would typically involve either ingestion or inhalation of these nuclides by the intruder. These scenarios, in turn, involve consideration of nuclide concentrations over large soil areas since the intruder must either breathe resuspended material or ingest material from contaminated foodstuffs. Both of these pathways have little dependency on localized hotspots as long as the average concentration over a large area is unaffected. Thus, if these pathways were the only consideration, encapsulation of alpha or beta-emitting sealed sources could be allowed over any reasonable disposed volume or, to a more limited degree, mass, that allowed compliance with the tabulated §61.55 concentration values. However, §61.41 also requires protection of the general population, and in the EIS, assumptions were made on the total sealed source activity disposed of at a disposal site. Furthermore, the inventory of alpha or beta-emitting sealed sources was also constrained by those source activities, that when averaged over the weight or volume of the encapsulated source in a 55 gallon drum, would lead to concentrations acceptable under the §61.55 concentration criteria. The revised Technical Position continues to reflect this limitation.

Disposal of primary gamma-emitters in activated materials or metals, or components incorporating radioactivity into their design

The guidance on these items evolves from the "sealed source" position. The possibility of exhumation at 500 years of sealed sources with activities typically ranging from 40 to 300 μCi was discussed above. If the same gamma-emitting activity were exhumed in the form of discrete activated materials or metals, or components incorporating radioactivity in their design, it would be highly unlikely that the hypothetical intruder would receive a dose greater than that calculated from the sealed sources because of the typical distribution of the activity over larger volumes and in materials that may exhibit a degree of self-shielding. Although these "dose reduction" aspects can not be generically quantified, when coupled with the conservative nature of the intruder-sealed source scenarios and dose constraints, it was

considered reasonable to always allow 1 mCi of gamma emitting nuclide in any exhumed piece of discrete waste as long as the activity of the nuclide when averaged over the waste volume in the disposal container containing the discrete waste, complies with the appropriate §61.55 concentration value.

The rationale in the preceding paragraph is also used to construct Table A in the Position which applies to situations in which larger components require sectioning as a result of operational considerations. The Table defines gamma-emitting activity levels in individual sections or pieces of larger components that, if not large enough to be treated as other than a sealed source (a piece with a volume less than 0.01 ft^3), should be individually considered when determining waste classifications. Essentially, the tabulated values assure that, either 100 years after disposal of Class A and B waste or 500 years after disposal of Class C waste, an intruder would not interact with more than 1 mCi of gamma-emitting activity in activated material or metal or in a component containing this radioactivity in its design.

Finally, since sealed sources, activated materials or metals, or components containing radioactivity in their design may be disposed of in the same disposal container with other waste of similar type containing the same gamma-emitting nuclide, acceptable concentration averaging guidance is included for these situations. One can always classify the disposal container based on the highest classification of any specific waste of a particular type contained in the container. However, if averaging is employed, the concentration of the the primary gamma-emitting nuclides in all discrete items in the disposal container is always considered acceptable if the concentrations in all the discrete items in the container are within a factor of 1.5 of the average concentration of the nuclide over all waste in the container. This factor of 1.5 precludes "hot spots" in gamma-emitting waste from significantly affecting projected intruder doses irrespective of whether the intruder is exposed through the intruder-agricultural scenario or through direct interactions with discrete waste (e.g.,handling scenarios). For example, in 5.6m^3 of containerized waste, 2.24m^3 could contain 0.3 Ci/m^3 of Nb-94 if the remaining waste contained Nb-94 at a concentration of 0.133 Ci/m^3. If the higher activity piece(s) were all exhumed and assumed to be at the surface of the disposal facility, the dose rate at 1 meter from the center of these piece(s) would be about 6 mrem/hr (e.g., assuming a circular piece with a radius of 3.34m and a thickness of 0.0635m (e.g., a piece of steel plate)). Considering an appropriate discovery or construction scenarios as described in the Environmental Impact Statement supporting 10 CFR Part 61, a projected dose to an intruder would not be expected to exceed 500 mrem/year.

<u>Disposal of alpha/beta emitters (nuclides other than primary gamma-emitters) in activated materials or metals, or components incorporating radioactivity in their design</u>

The guidance on activity, other than the primary gamma-emitters, in these items also reflects the "sealed source" position described above. In this case, the Position defines a "mixing" constraint that is within the context of the general waste classification rationale expressed in the documentation that supported the Part 61 regulation. In defining this constraint, it was noted that the §61.55 concentration values that delineate the boundaries between

different waste classes (i.e.,A, B, C, and GTCC) typically differ by more than one order of magnitude. Also, as noted previously, the potential dose to an intruder from alpha/beta activity, or the small quantities of gamma activity associated with nuclides other than Co-60, Nb-94, and Cs-137/Ba-137m, is essentially independent of localized "hot spots". As a result, the guidance in the Position allows concentration averaging of the alpha/beta emitting activity in individual items if all the concentrations in the individual items within a disposal container are within a factor of 10 of the average concentration over all items in the container.

The rationale in the preceding paragraph is used to construct Table B in the Position which applies to situations in which larger components require sectioning as a result of operational considerations. Since any potential intruder dose is essentially independent of alpha/beta (or non-primary gamma-emitter) "hot spots", the numerical values in the table reflect the maximum activity that would be allowed if the activity was contained in a sealed source, and a minimum volume criterion is not necessary.

Other Discrete Waste Types

The guidance in the Position for other discrete waste types (i.e., contaminated materials and cartridge filters) follows the rationale discussed above.

Alternative Provisions

Since the Position is not intended to provide guidance on all conceivable concentration averaging methods, the "Alternative provisions" paragraph is a critical feature in the Position. This paragraph indicates that other concentration averaging positions can be considered acceptable if it can be demonstrated with reasonable assurance that their application will not compromise any of the performance objectives in Subpart C of 10 CFR Part 61.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

FIRST CLASS MAIL
POSTAGE AND FEES PAID
USNRC
PERMIT NO. G 67