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7. Abstract

A dose assessment has been performed for materials that may contain radioactivity, but at levels that are indistinguishable from background. The authorized release levels are concentrations that correspond to detection limits for each significant radionuclide. Those levels will be used as criteria for unconditional release of materials and equipment. The assessment was performed by comparison with scenarios for disposal or reuse that are already available in the literature. Potential doses were found to be less than a few mrem/y.

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TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 SUMMARY 2

3.0 EXPOSURE SCENARIOS 3

4.0 REFERENCES 6

1.0 INTRODUCTION

Cost-effective management of surplus materials and equipment requires a determination of whether the material can be released from radioactivity controls, since controlled storage or disposal would otherwise be required for all material, even if not radioactive. Such controls are more expensive than release to uncontrolled facilities, and preclude recycle or reuse of the material. However, all material contains natural radioactivity, so a criterion is required to determine that the material can be released. For release of potentially radioactive material, criteria for surface contamination, volumetric contamination for U/Th+D in soil, and levels in air and water are given in U.S. Department of Energy (DOE) Order 5400.5 (DOE 1990). However, volumetric criteria for other radionuclides have not been established, except through case-by-case determination.

Presently, the DOE Office of Environment, Safety and Health (DOE-EH) intends to maintain its case-by-case approach to establishing authorized limits for release in 10 CFR Part 834, but will be providing specific guidance on the development of protective criteria for release of radioactive material. The DOE-EH is working with the U.S. Environmental Protection Agency (EPA) and the U.S. Nuclear Regulatory Commission (NRC) in the development of release criteria which will be included in 10 CFR Part 834 when they are developed. Until specific authorized limits for release are developed consistent with 10 CFR Part 834, or EPA issues generic release criteria which are incorporated into 10 CFR Part 834, it is desirable to establish interim criteria for cost-effective materials management that are based on the "indistinguishable from background" concept.

The current DOE approach to interim release criteria (Lytle 1992) is to make a showing of no detectable radioactivity added from DOE activities ("no-rad-added,") since this should be more conservative than the developing dose-based criteria for release of "residual radioactive material," which would presumably allow some nominal amount of radioactivity to remain in released materials. It is noted that the criteria for release of residual radioactive material do not address the question of whether the material is actually radioactive or not (some residue is assumed), but the "no-rad-added" principle seems to do just that.

The Westinghouse Hanford Company (WHC) approach has been to define "no-rad-added" as meaning that the radioactivity content is indistinguishable from background, as measured by the laboratory detection limits in Table J1-b of WHC-EP-0063-4 (WHC 1993). This approach was accepted by DOE (Lytle 1993) for establishing the criteria for distinguishing between mixed waste (which must be stored) and hazardous waste (which can be processed and disposed of without concern for the radioactive content). Since the approach basically defines what is radioactive and what is not, WHC has notified DOE-Richland Field Office (RL) (Dixon 1995) that these levels would also be used as interim criteria to determine what is acceptable for unrestricted release, as having no detectable added radioactivity. However, an informal request was received from RL to do a dose assessment for these limits, as they might be used for the purpose of unrestricted release, and that assessment is provided here.

The technical approach to the assessment is to consider human activity scenarios that might lead to exposure of persons who could use the released materials in various ways, without knowledge of any unusual content. The scenarios are intended to be reasonable and conservative, but not worst-case, in keeping with DOE Order 5400.5 (DOE 1990) and associated guidance (DOE 1991 and 1993) and with guidance from the Performance Assessment Task Team (Wood 1994). A substantial amount of work has already been performed in this area for DOE, NRC, and EPA decommissioning and residual radioactivity studies, so the results can be extrapolated from existing literature. The scenarios are typically for residential, construction, or recycle activities, including special consideration for potential groundwater transport for those few radionuclides that might have more impact through that transport pathway.

The discussion includes development of exposure scenarios by analogy to existing studies, followed by dose estimation for the concentration limits proposed as unconditional release limits. No specific dose limit has been established for release of materials and equipment, although guidance is available from past and proposed practices. The DOE approach to decomissioning on a case-by-case basis has been to apply an individual dose constraint below the 100 mrem/y primary dose limit (e.g., 30 mrem/y), plus the as low as reasonably achievable (ALARA) process, with the goal being to establish an authorized limit that ensures doses are well below the primary dose limit (on the order of a few mrem/y or less). The NRC and EPA are developing cleanup and release criteria that are based on an annual individual dose limit of 15 mrem, which is consistent with the DOE approach. Some states have applied an annual limit in the 10-15 mrem range for similar purposes. Thus the approach here will be to compute doses corresponding to the detection limits, while not actually specifying a dose limit, since that process would follow later when DOE provides guidance on residual radioactive material.

2.0 SUMMARY

Detection limits in Table J1-b of WHC-EP-0063-4 were previously established as the appropriate levels to define "no-rad-added," in the context of being indistinguishable from background, for the purpose of releasing potential mixed waste to management as hazardous waste. These limits have also been used as interim criteria for unconditional release, until guidance is received on development of final release criteria, which would be based on a dose limit for exposure to the small amounts of radioactivity that would remain under a dose-based criterion. A dose evaluation for exposure to material released under the interim criteria has been performed by conservative extension of scenario analyses and dose calculations in existing literature. The annual individual dose from released material is projected to be a few mrem, or less, which is a very small fraction of the DOE annual limit of 100 mrem.

3.0 EXPOSURE SCENARIOS

Estimation of possible doses from materials which have been unconditionally released is done by analyzing usage scenarios which involve potential exposure to those materials. Many possible exposure scenarios for released material have been developed and analyzed in the literature. The most relevant scenario sets found were in NUREG-1500 (NRC 1994) for residual radioactivity left in sites or buildings to be released, and International Atomic Energy Agency (IAEA) Safety Series No. 111-p-1.1 (IAEA 1992) for materials recycled for reuse. Potential exposures are estimated here by comparison to results of those two studies.

The NUREG-1500 analysis included four scenarios: residential, building occupancy, building renovation, and drinking water. These were chosen as limiting cases for the many potential activities that might be postulated for released buildings and sites. The results are expressed as doses per unit concentration in, or on, soil and buildings. The residential scenario is the most limiting, and will be used for comparisons here (recycle scenarios are considered later). The details of the scenario are to be developed by the user, based on the dose factor, which is given as mrem/y per pCi/g of a radionuclide in an infinite layer of soil, 15 cm thick. The dose factor for the residential scenario combines exposure pathways for inhalation, external exposure, ingestion of contaminated drinking water, and ingestion of contaminated soil and agricultural products, including fish from a pond. The model for irrigation of crops includes percolation through 1 meter of soil to an aquifer which discharges directly into a pond, which is used for irrigation and growing fish, basically in a recycle mode. No retardation of radionuclides is assumed.

The details to be provided include a mechanism for released material to be combined with the soil, and a number of other details which are of lessor impact and need not be considered here (although they would be necessary for a future detailed derivation of dose-based allowable residual radioactivity). The impact of one, or a few, released items would be small, due to the low potential for significant contact or exposure times to occur. Thus, a mechanism for longer contact times with substantial volumes is specified here. If the selected limits are applied to all released items, only a few will be close to the limits, with the rest substantially lower in concentration or not contaminated at all, so an average concentration is calculated for the amount of material involved in the scenario. Typical peak-to-average ratios would be in the range of 50 to 100, or higher, but a conservative value of 10 is chosen, which is the value used by the NRC in the development of limits in 10 CFR Part 61 (NRC 1981). Thus the average concentrations of radioactivity in the released material are taken as 10% of the detection limits in Table J1-b of WHC-EP-0063-4.

One likely method for released material to combine with surface soil, at least in substantial quantities, would be for material to be routinely placed in a landfill, part of which is later excavated as part of residential basement construction. This scenario is routinely analyzed in performance assessments for disposal of low-level waste. In the scenario, waste is inadvertently excavated (a few tens to hundreds of cubic meters) and spread over a few hundred to a few thousand square meters to a typical tilling depth of 15 cm. The details vary, but the result is a mixing ratio of 5 to 100, or more (Seitz 1994). A value of 5 is chosen here for conservatism. Thus the concentrations of released material in the top layer of soil in the resident scenario are 50 times smaller than the values in Table J1-b of WHC-EP-0063-4 (factor of 5 for spreading times factor of 10 for peak-to-average ratio). Additional reductions would occur if the fraction of diet from onsite, fraction of dust from onsite, and fraction of time spent onsite were to be less than one, or if the groundwater usage parameters were chosen more realistically. These considerations are not included here, but may be desirable for future development of dose-based residual radioactivity limits.

The potential doses may now be calculated from the product of the average concentrations in surface soil (one-fiftieth of the detection limits in Table J1-b) times the dose factor in the last column of Table A-1 (mrem/y for 1 pCi/g in the infinite layer, 15 cm thick) of NUREG-1500. Those doses are listed below for significant radionuclides.

Radionuclide	Detection Limit/50 (pCi/g)	Annual Dose for 1 pCi/g (mrem)	Annual Dose for D.L./50 (mrem)
Co-60	0.2	5.1	1.0
Cs-137	0.2	1.4	0.7
Eu-154	0.2	2.5	1.0
Na-22	0.2	4.1	0.84
Tritium	8	0.036	0.29
C-14	1	0.41	0.41
Sr-90	0.2	1.3	0.26
Tc-99	0.6	0.29	0.17
I-129	0.5	35.5	18
Np-237	0.04	80	3.2
Pu-239	0.04	8	0.32
Pu-241	0.6	0.24	0.14
Am-241	0.04	8.2	0.33
Cm-244	0.04	4.4	0.18

The most significant radionuclides are I-129 and Np-237, but that result is an artifact of the extremely conservative groundwater recycle approach to irrigation. Actually I-129 should be removed from the list of radionuclides significant to release, because if the fission products (e.g., Sr-90 or Cs-137) are below their detection limits, the I-129 will also be below its detection limit. The ratio of Cs-137 to I-129 in average spent fuel (decayed to 1990) is about 5,000,000. Various treatments might have reduced this ratio

by 2 or 3 orders of magnitude for special cases, but the ratio would still be at least 1000. The ratio of doses per unit concentration is only about 25, so I-129 is not a radionuclide of concern for released material. The same logic was previously accepted for eliminating Se-79 from the existing table (footnote to Table J1-b of WHC 1993).

The dose from each of the remaining listed radionuclides is a very small fraction of the DOE individual annual dose limit (100 mrem), and a small fraction of the annual dose limits under consideration for residual radioactivity and decommissioning purposes (10-30 mrem). It might be possible for 2 radionuclides to be near their detection limits in the same sample, which might increase the dose, but additional combinations near their limits are unlikely. Gross alpha and gross beta scans are also part of the analysis, and would indicate potential combined contributions. Further reductions in dose projections might be achieved by consideration of additional conservatisms in the source documents. Those considerations are not necessary for the present purpose, but would be useful for future development of final criteria, when guidance on acceptable doses and methodology becomes available from DOE-EH.

Other scenarios for exposure to released materials could include recycle and reuse. The potential impacts of these activities are analyzed in IAEA Safety Series No. 111-P-1.1 (IAEA 1992). This document gives dose factors for activities related to recycling steel, aluminum, and concrete (100 tons of each), as well as buildings, tools, and equipment. Results are given as dose per unit concentration in tables in Appendix III. Conclusions are stated as potential exemption levels in terms of concentrations (Becquerels/g, or 27 pCi/g, of uniform contamination) per unit dose (10 microsieverts/y, or 1 mrem/y). For recycle, the factor of 10 for peak-to-average applies, but the factor of 5 for mixing in soil is not appropriate. Thus the detection limits divided by 10 were used for comparison. The lowest limiting concentration in Table XX of IAEA 111-P-1.1 is for Co-60. Recycle of steel contaminated with Co-60 to make automobiles is the example. Our detection limit divided by 10 is 1 pCi/g. The dose factor (Table VIII of IAEA 111-P-1.1) is 0.1 Bq/g of Co-60 corresponds to an annual dose of 10 microsieverts. Converting this to current units, 1 pCi/g corresponds to 0.4 mrem/y, which is smaller than the dose from Co-60 in the landfill scenario. Inspection of the IAEA tables shows that Co-60 is the limiting radionuclide, in terms of dose relative to detection limit. Thus the recycle scenarios are not as limiting as the resident-on-landfill scenario, and are not considered further.

Doses from DOE activities are also required to be reduced to levels that are as low as reasonably achievable (ALARA). In this case the concentrations will be at, or below, detection limits, so there is no practical way to determine achievability of further reductions. Thus the criteria meet the ALARA requirement.

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