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A PROPOSED CLASSIFICATION SCHEME FOR HIGH-LEVEL AND OTHER RADIOACTIVE WASTES*

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INTRODUCTION

The Nuclear Waste Policy Act (NWPA) of 1982 defines high-level radioactive waste (HLW) as:

> "(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel .... that contains fission products in sufficient concentrations; and
>
> (B) other highly radioactive material that the Commission .... determines .... requires permanent isolation."

This paper presents a generally applicable quantitative definition of HLW that addresses the description in paragraph (B). The approach also results in definitions of other waste classes, i.e., transuranic (TRU) and low-level waste (LLW).

HLW traditionally has been defined as waste from fuel reprocessing [e.g., see paragraph (A) above]. However, waste from fuel reprocessing

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has certain intrinsic characteristics, related to short-term risks from waste management and operations and to long-term risks from waste disposal, that can be used to develop generally applicable definitions of HLW and other waste classes, including:

- high concentrations of fission products, principally ^{90}Sr and ^{137}Cs, resulting in high rates of heat generation and external exposure; and

- high concentrations of long-lived radionuclides, principally alpha-emitting TRU isotopes, having high radiotoxicities.

CONCEPTUAL DEFINITIONS OF HLW AND OTHER WASTE CLASSES

On the basis of paragraph (B) of the NWPA and other historical precedents,[1] and the intrinsic characteristics of reprocessing waste, we propose the following conceptual definition:

HLW is waste that is -

(1) highly radioactive and

(2) requires permanent isolation.

Thus, we regard HLW as having two distinct attributes. We associate "highly radioactive" with short-term risks and "requires permanent isolation" with long-term risks.

This definition of HLW leads to the following definitions of TRU waste and LLW:

- TRU waste is waste that "requires permanent isolation" but is not "highly radioactive;" and

- LLW is waste that does not "require permanent isolation," without regard to whether it is "highly radioactive."

The definition of TRU waste includes radionuclides other than long-lived, alpha-emitting TRU isotopes. The definition of LLW is consistent with the NRC's 10 CFR Part 61.[2,3]

QUANTITATIVE DEFINITIONS OF "HIGHLY RADIOACTIVE" AND "REQUIRES PERMANENT ISOLATION"

We relate "highly radioactive" to high levels of decay heat (power density) or external exposure. On the basis of the maximum concentrations of ^{90}Sr and ^{137}Cs that are acceptable for disposal as Class-C LLW,[2] we propose that:

"highly radioactive" means -

(1) a power density greater than 50 W/m^3 or

(2) an external exposure rate at a distance of 1 m from unshielded waste greater than 100 R/h.

We relate "requires permanent isolation" to high concentrations of long-lived radionuclides, and we propose that:

"requires permanent isolation" means concentrations of radionuclides that exceed the limits acceptable for disposal as Class-C LLW, as defined in the NRC's 10 CFR Part 61.[2-4]

SUMMARY OF BASIC WASTE CLASSIFICATION SCHEME

The basic waste classification scheme that results from the quantitative definitions of "highly radioactive" and "requires permanent isolation" is depicted in Fig. 1. The concentrations of radionuclides that correspond to these two boundaries, and that may be used to classify radioactive wastes, are given in Tables 1 and 2.

REFERENCES

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Table 1. Selected radionuclide concentrations corresponding to "highly radioactive" boundary[a]

Nuclide[b]	Boundary concentration (Ci/m^3)	Nuclide[b]	Boundary concentration (Ci/m^3)
C-14	2E5	U-232 + d	2E2
Ni-63	5E5	Pu-238	2E3
Sr-90 + d	7E3[c]	Pu-239	2E3
Cs-137 + d	5E3[c]	Pu-240	2E3
Sm-151	4E5	Pu-241	2E6
Pb-210 + d	1E3	Am-241	2E3
Ra-226 + d	3E2	Am-243 + d	1E3
Ac-227 + d	2E2	Cm-243	1E3
Th-229 + d	3E2	Cm-244	1E3
Pa-231	2E3	Cm-245	2E3

[a]Boundary concentration for any radionuclide is based on power density of 50 W/m^3 or external exposure rate of 100 R/h; "highly radioactive" boundary for wastes containing mixtures of radionuclides is determined from boundary concentration for each radionuclide using sum-of-fractions rule.

[b]Notation "+ d" denotes short-lived daughter products assumed to be in secular equilibrium.

[c]Limit for disposal as Class-C low-level waste.[2]

Table 2. Selected radionuclide concentrations corresponding to "permanent isolation" boundary[a]

Nuclide	Boundary concentration (Ci/m^3)	Nuclide	Boundary concentration (Ci/m^3)
C-14	8	U-234	8E-1
C-14[b]	8E1	U-235	2E-2
Ni-59[b]	2E2	U-238	2E-1
Ni-63	7E2	Np-237	4E-2
Ni-63[b]	7E3	Pu-238	7
Sr-90	7E3	Pu-239	1E-1
Nb-94[b]	2E-1	Pu-240	1E-1
Tc-99	3	Pu-241	5
I-129	8E-2	Pu-242	1E-1
Cs-135	8E2	Am-241	1E-1
Cs-137	5E3	Am-243	7E-2
Ra-226	3E-2	Cm-243	8E1
U-233	8E-1	Cm-244	4E1

[a]Boundary concentration for any radionuclide defined as limit for disposal as Class-C low-level waste;[2-4] "permanent isolation" boundary for wastes containing mixtures of radionuclides is determined from boundary concentration for each radionuclide using sum-of-fractions rule.

[b]Activated metal.

Fig. 1. Depiction of basic waste classification scheme. Radionuclide concentrations corresponding to boundaries separating high-level, transuranic, and low-level waste are given in Tables 1 and 2.

QUANTIFICATION OF BASIC WASTE CLASSIFICATION SCHEME